RAF operational requirements 1923-1939.

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ABSTRACT

Operational requirements defined the aircraft performance characteristics which the RAF saw as needed to implement its doctrine of air warfare. They initiated the process of specification-design-development-production of service aircraft. This thesis examines the evolution of the RAF's operational requirements for its home defence air force - for bombers to mount a deterrent counter offensive and for fighters to provide direct defence of Britain.

The treatment is historical. The aim is to consider the management processes, policies and decisions relevant to operational requirements in the context of their own time. This approach shows the Air Ministry in a more favourable light than have studies based upon inadequate research and undue hindsight.

By tracing the development of operational requirements the thinking behind the RAF's quest for effective fighter and bomber aircraft is exposed. It is shown that the requirements set in the mid-1930s - which led to the aircraft with which the RAF entered and fought the Second World War - owed much to ideas and concepts of air warfare which had first been adopted many years earlier.

The research gives a new perspective on the origins of many well-known British aircraft of the Second World War. It is found that commonly accepted descriptions of these are unsound or incomplete, and an authoritative account taken from primary sources is given.

It is concluded that, although the RAF's perception of the pattern of future air warfare proved to be wrong, its operational requirement policies led to aircraft which were at least as good as those of other countries. Moreover, in many respects the RAF had sought aircraft performance characteristics which could be exploited in the actual combat situations which emerged in 1939-40 and later.

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ABBREVIATIONS

A & AEE	Aircraft and Armament Experimental Establishment
ACAS	Assistant Chief of the Air Staff
ACAS(T)	Assistant Chief of the Air Staff (Tactics and Requirements)
ACM	Air Council Memorandum
ACM	Air Chief Marshal
ADC(A)	Assistant Director Contracts (Aircraft)
AD/RDA, ADRDA	Assistant Director, Research and Development (Aircraft)
ADArm	Assistant Director (Armament)
ADGB, A.D.G.B.	Air Defence of Great Britain
AD of C.A.	Assistant Director of Contracts (Aircraft)
AD/RD	Assistant Director Research and Development
AD/RDL	Assistant Director Research and Development
AHB	Air Historical Branch, Ministry of Defence
AFC, A.F.C.	Air Fighting Committee
AI	Air Intelligence
AM, A.M.	Air Marshal
AMDP	Air Member for Development and Production
AMRD	Air Member for Research and Development
AMSO	Air Member for Supply and Organisation
AMSR	Air Member for Supply and Research
AOC	Air Officer Commanding
AOC-in-C	Air Officer Commanding-in-Chief
ARP	Air Raid Precautions
ASM	Air Staff Memorandum
AVM	Air Vice Marshal
CID, C.I.D.	Committee of Imperial Defence
COW, C.O.W.	Coventry Ordnance Works
CAS	Chief of the Air Staff
CIGS	Chief of the Imperial General Staff
DArmD	Director of Armament Development
DCAS	Deputy Chief of the Air Staff
DDGP	Deputy Director-General Production

DDI	Deputy Director Intelligence
DDOI	Deputy Director of Operations and Intelligence
DDOps	Deputy Director Operations
DDOR	Deputy Director Operational Requirements
DDPlans	Deputy Director Plans
DDRD	Deputy Director Research and Development
DD/RDA	Deputy Director Research and Development Aircraft
DDTD	Deputy Director Technical Development
DGRD	Director-General Research and Development
DNO	Director of Operations (Naval Co-operation)
DoC	Director of Contracts
DoE	Director of Equipment
DOI	Director of Operations and Intelligence
DoO	Director of Organisation
DOps	Director of Operations
DOR	Director of Operational Requirements
DOSD	Director of Organisation and Staff Duties
DoT	Director of Training
DSD	Director of Staff Duties
DTD	Director of Technical Development
DTSD	Director of Training and Staff Duties
EPM	Expansion Progress Meeting
FO1	Flying Operations 1
FO2	Flying Operations 2
GP	General Purpose
IDC	Imperial Defence College
JRAeS	Journal of the Royal Aeronautical Society
JRUSI	Journal of the Royal United Services Institution
JSS	Journal of Strategic Studies
M&AEE	Marine and Armament Experimental Establishment
MAP	Ministry of Aircraft Production
mph, m.p.h.	statute miles per hour
NACA	National Advisory Committee for Aeronautics
OR	Operational Requirements

PRO	Public Record Office
PS	Private Secretary
PUS	Permanent Under-Secretary
RAE	Royal Aeronautical Establishment
RAeS	Royal Aeronautical Society
RAF	Royal Air Force
RDA	Research and Development Aircraft
RDArm	Research and Development Armament
RDT	Research and Development [Technical]
SASO	Senior Air Staff Officer
SD	Staff Duties
S.E.	single engined
SoS	Secretary of State
S/S	single seater
SSF, S.S.F.	single seat fighter
SSIF	single seat interception fighter
T.E.	twin engined
USAAF	United States Army Air Force
USoS	Under Secretary of State

1. INTRODUCTION

1.1 SCOPE OF RESEARCH

When the Second World War started in September 1939 the RAF began hostilities with aircraft types which had been conceived, designed and developed many years earlier. They resulted from the RAF's perception of the aircraft it would need to carry out its duty of home defence against air attack. To the RAF home defence did not mean just the interception and destruction of attacking aircraft, for it did not believe that such a defence could be effective. It believed that the most effective defence against air attack was an offensive against an enemy's means to wage war - its industry and morale - and the home defence force was first planned to have twice as many bombers as fighters.

This thesis is concerned with the translation of that overall policy into operational requirements, which is how the RAF expressed its view of the aircraft characteristics it needed to carry out its duties. Through tracing the development of operational requirements in the 1920s and 1930s the thinking behind the RAF's quest for effective fighter and bomber aircraft is exposed, and this leads to a new perspective on the origins of many of the aircraft with which the RAF entered and fought the Second World War. It is found that commonly accepted descriptions of these origins are unsound, and an authoritative account taken from primary sources is given.

The treatment is historical. The aim is to consider the Air Ministry policies and decisions in the context of their own time. The purpose is not to pass judgement from the standpoint of knowing what strategy or tactics proved to be effective, and those that did not. Nor is it to assess aircraft designs based on knowledge of those which later proved successful, and to blame the Air Ministry for not knowing what the best line of development would turn out to be. It will be seen that this approach puts the Air Ministry in a more favourable light than do studies based upon hindsight.

In the Official History on Design and Development of Weapons, Postan *et al*[1] explain how analyses and discussions of operational requirements were the starting point in the process of specification-tender-design-development-production through which aircraft evolved into operational use. They represented an assessment of future needs, and of the operational possibilities which might follow from the exploitation of new or developing technology. In the words of the Official History,

> In the first place the tactical and strategic ideas of the Services had to be focussed (sic) on problems of aircraft or aircraft equipment. This meant considering and defining to what extent the quality of existing types met, or failed to meet, the requirements of the men who flew them and what further improvements in quality, i.e. speed , range, load etc., would be necessary. In the terminology of the R.A.F. administration this function was described as 'O.R.' (Operational Requirements) and expressed the 'user' point of view in the narrower sense of the term.[2]

Postan's second stage was design and development, and indeed that is the subject of the Official History. He says of the first stage,

> The method in which the first of those functions, i.e. formulation of operational requirements, was fulfilled need not delay us long. The fact that it followed directly from the strategic notions of the Air Staff or from the tactical experience of the Royal Air Force made it an integral part of the Air Staff duties.[3]

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[1] Postan, M.M., Hay, D., Scott, J.D., Design and Development of Weapons, 1964
[2] ibid., page 45
[3] ibid., page 46

It is the performance of those duties which is the subject of this thesis, and, as Postan noted, it was not restricted to the Air Staff. This is brought out in a review of the management process for setting operational requirements in the Air Ministry in the 1920s and 1930s.

In the 1930s the vital planning task of assessing future operational requirements was particularly complex. There had been no recent combat experience from which operational lessons might be learnt, and until late 1934 there was uncertainty as to the potential enemy. Most crucially, very rapid advances in aeronautical engineering were taking place. These offered new operational possibilities, but also new threats, with the ever-present risk of commitment to a level of technology which might have become out-dated by the (unknown) time that hostilities arose. It was against that background that decisions were made which led to the majority of the home defence aircraft types which the RAF operated in the early years of the Second World War. Some of these types, albeit much modified, formed the backbone of the RAF throughout the war.

A study of the development of operational requirements highlights debates within the Air Ministry on the expected operational and tactical effectiveness of the aircraft which were sought. It will be seen that, although the Air Ministry was fully aware of the need to exploit the air-fighting potential of advances in aeronautical engineering and armament, this did not alter its belief in the effectiveness of bombers and bombing. In consequence there was much concern with the problem of the direct defence of London against hostile bombing formations. This problem was not thought to have been solved even by the heavily-armed fighters developed in the 1930s. Fears that single-seat fighters would be ineffective in breaking up formations of bombers led to much effort being put into the search for a superior type of fighter.

Faced with its presumed ineffectiveness in direct defence, the RAF adopted the strategy of a counter-offensive to deter or mitigate air attacks on London. It planned to implement this through precision bombing in daylight. When Germany replaced France as the potential enemy, this brought a requirement for deep penetrations of hostile air space, and it will be shown that it was the consequent need for high speed and heavy armament which led to a move towards heavier bombers in the 1930s - not a change in bombing policy. Paradoxically, the heavy night bombers of 1941-45 were a product of these day bomber requirements - aided by plans for overload operation using exotic schemes for assisted take-off. It will be seen that when these were not forthcoming larger airfields were built, and that attainable fighter performance was also dictated by airfield size.

1.2 LITERATURE REVIEW

Published material of some relevance to the current research is of three kinds - that dealing primarily with British air policy and strategy, that describing the operations and campaigns of the RAF, and that describing the development and operations of particular aircraft types. It is convenient to discuss the literature under those headings. They are not mutually exclusive, for often works on air policy stray into descriptions of aircraft development, and similarly the literature on RAF operations and on aircraft development frequently includes the authors' views on political developments and supposed RAF policy of the day. Such cross-referencing is often found to be inaccurate, and can lead to interpretations of policy based upon a false view of RAF aircraft and intentions for their development.

One reason for this is that few works on aviation history make reference to operational requirements, either as the means by which the Air Staff sought to implement its doctrine of air warfare or as the origin of the aircraft which entered service in the RAF. It is commonly assumed that an Air Ministry specification (which it will become evident has sometimes not been read) was the genesis of a particular type. Many writers suggest that even these were produced only in response to an initiative from the aircraft industry. The present research will show that this was seldom, if ever, the case.

The weakness of picking up the history of development of an aircraft type at the specification stage is that it can miss the Air Staff's intentions, often vital to the understanding of the specification and of the later development of the aircraft concerned. A consequence of this omission is that there is little recognition of the concepts of zone and interception fighters, of the demand for fast bombers to limit exposure to fighter attack in daylight, of the trade-off of armament and fuel weight against performance and endurance, and of the vital importance of the size of airfields. These are matters over which the Air Ministry agonised, and had to come to some decision, however imperfect it can be said to have been in retrospect. In discussing these decisions in the following chapters reference will be made where appropriate to such errors and misunderstandings in the literature.

An incomplete description of the RAF's perception of the aircraft it needed is of little consequence to the vast majority of works on the RAF (except as a source of polemic bias), because they are primarily concerned with the development of established aircraft types and/or their operational history. However, a few writers have based their criticisms of RAF policy on the supposed decision-making process and decisions concerning operational requirements. Misunderstandings or errors here can lead to unsound conclusions concerning policy, management, and aircraft development. Literature of this kind is discussed in the following section. It is followed by comments on some common errors that are found in campaign and aircraft histories.

1.2.1 Air Policy and Strategy

A publication which leans heavily on the consideration of operational requirements to argue a case for a supposed change in RAF policy is British Air Strategy between the Wars by Malcolm Smith.[4] Smith asserts that during the years of re-armament in the 1930s the RAF moved from a policy of "strategic interception" to one of out-and-out strategic bombing, and that this followed from a need to standardize equipment so as to obtain maximum production. He says,

> The Air Staff was then forced to examine in more detail than previously the operational requirements necessary to execute their theory of air warfare.[5]

Smith writes that in the 1930s the Government decided to build up the air strike force as a deterrent to Germany, and that technical developments in aircraft design made specialisation of aircraft roles increasingly essential - a doubtful assertion. He claims that production problems forced the RAF to limit the number of types of aircraft it could develop, although they had wanted to keep their options open to maintain flexibility, which their theory of strategic interception demanded. Smith says,

> Faced with a decision on which role they considered the most important, the Air Staff plumped for the long-range heavy bomber. In these ways, the admirably flexible policy of strategic interception was to be gradually simplified and whittled down to a

[4] Smith, M., British Air Strategy between the Wars, 1984

[5] ibid., page 231

> much more rigid and specific war aim in the years after Trenchard left office.[6]

Whether or not the Air Staff did consciously alter its bombing policy is not the subject of this thesis. But whether or not the formulation of the Air Staff's views of the operational capabilities it sought from its aircraft was driven by such a change is highly relevant. Smith discusses this question in his Chapter 8, entitled "Equipment and Production Policy".[7] Bearing in mind that Smith is suggesting that technical considerations had a major influence on Air Staff policy formulation, it is unfortunate that this key chapter has many technical inaccuracies. For example, the second page includes the statement that "The standard RAF aircraft of the early 1930s was an all-wooden biplane with air-cooled engine, open cockpit, and fixed undercarriage."

In fact, as discussed in chapter 4, the Air Ministry adopted a metal aircraft policy in 1925, and by 1930 there were no wooden aircraft in front-line service. Smith contradicts his reference to air-cooled engines by then mentioning the Hawker Fury and Hart as examples of early 1930s aircraft; both had liquid-cooled engines. He refers to "R. Fedden of Rolls Royce" as contributing to the Supermarine S.6, "three-times winner" of the Schneider Trophy contest.[8] Fedden's name was synonymous with Bristol engines and he never worked for Rolls-Royce;[9] the three successive Schneider Trophy wins were by the Supermarine S.5 (Napier engine), S.6 and S.6B.[10]

These errors of fact by Smith do not bode well for his appraisal of the development of operational requirements for bombers and from which Smith deduces a major change in RAF doctrine. However, the subject of Smith's book is

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[6] ibid., page 75
[7] ibid., page 229
[8] ibid., page 238
[9] Gunston, Bill, By Jupiter: the Life of Sir Roy Fedden, 1978
[10] Barker, R., The Schneider Trophy Races, 1971

British Air Strategy, and changes in that can reasonably be expected to be reflected more in the planned numbers of aircraft of different types rather than in the characteristics of each type, not least because these characteristics were always changing to take advantage of improvements in aviation technology. On that basis the successive expansion plans for the RAF from 1934 to 1938 certainly indicated a shift of intention towards heavier bombers,[11] but that was driven by the technical problems of bombing Germany rather than France.

The current research will show that in 1937-38 the RAF did indeed seek a standard bomber for all roles, but not a role to suit a standard bomber as suggested by Smith.

The development of the Air Staff's operational requirements for bombers is described and discussed later in this thesis. It will suffice to note here that Smith under-estimates the consequences for bomber design of the range that was required, particularly when long range was coupled with deep penetration of hostile air space. When Berlin replaced Paris as the target, bomber aircraft were going to get much heavier, whatever the bombing policy.

Divine's The Broken Wing[12] also uses examples of the RAF's aircraft development policy to make a case for a discussion of wider issues; in his case a general claim of incompetence against the Air Ministry. But, like Smith, his citing of technical issues is unsound and in places verges on the ridiculous. He makes unsubstantiated comparisons with other air forces and cites requirements which did not exist. Typical of the former is his claim that,

> The Air Force that Sir John Salmond inherited [he replaced Trenchard as CAS on 1st January 1930] was cocooned in the era of the fixed undercarriage fabric-covered biplane.

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[11] Smith, Expansion Schemes A-M, pages 328-335

[12] Divine, D., The Broken Wing, 1966

> The Air Forces of other nations were already emerging from it.[13]

He does not indicate which other nations these were. None are known to the present writer, nor more pertinently to Richard Fairey, a leading aircraft designer of the 1920s and 1930s. His view that in 1931 British military aircraft enjoyed "technical precedence" is quoted shortly.

An example of Divine's disregard for facts is his discussion of the origin of the RAF's monoplane fighters. He says that,

> Early in 1930 Sir Hugh Dowding, then Air Member for Research and Development, decided to utilise part of his appropriation for the design of a fast experimental aircraft in the fighter range,

and that this "requirement" indicated "an improvement in the position of the younger fighter school."[14] But Dowding was not appointed as Air Member for Supply and Research until 1st September 1930[15] (there was no post of AMRD until 1935), and as AOC Fighting Area, Air Defence of Great Britain (ADGB), before then he had no appropriation for experimental aircraft. Moreover, discussion of the operational requirements which led to specification F.7/30 (to which Divine is referring) was initiated in 1929 (see chapter 5). Divine then criticises this specification on the grounds that it called for no "shape", asked for a low landing speed, and "only 250 m.p.h, arriving at that figure presumably by adding 20 m.p.h. to the previous requirement."[16]

Specification F.7/30 was for a Bulldog replacement, and that "previous requirement" had a maximum speed of 173 mph.[17] As discussed in chapter 5, the Air Staff actually

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[13] ibid., page 179

[14] ibid., pages 179-180

[15] this and other appointments are taken from the Air Force Lists

[16] Divine, page 180

[17] PRO: AIR 2/2815, Single Seat Fighter - Low Wing Monoplane (Bulldog Replacement) Type Requirements Specn. F.7/30, DCAS to CAS, 31.5.30

sought 215 mph for F.7/30, and the AMSR's Department, first under Higgins and then under Dowding, pushed this down to 195 mph. Divine also seems unaware that the day and night operational capability specified by the Air Staff for the standard RAF fighter had always required a relatively low landing speed (F.7/30 actually included the highest yet allowed).

Divine suggests that F.7/30 indicated Air Ministry bureaucratic incompetence in the same way as did his earlier comparison between the Fairey Fawn (an over-specified failure) and the Fairey Fox (a private venture success). But this is a "broken stick" with which to beat the Air Ministry in the 1930s, for in February 1931 Richard Fairey himself said of the Air Ministry's relations with manufacturers that,

> it may be assumed from the technical precedence which this country at present enjoys that for the time being at least our system is working quite well, and that the military and technical sides are cooperating successfully.[18]

Divine also appears not to understand the role of the ADGB Command, for he says that "The air element of A.D.G.B. and in due course Fighter Command were through the greater part of the 'tween war period the step-children of the R.A.F.".[19] But the "air element" of the ADGB was primarily intended to be a bomber force, inherited by Bomber Command in 1936.

Other misrepresentations of Air Ministry policy - and staffing - in The Broken Wing will be noted in later chapters.

Higham is a writer on British military history who also uses inaccurate technical details and unsubstantiated statements as evidence for his criticism of the Air

[18] Fairey, C.R., "The Future of Aeroplane Design for the Services", JRUSI, Vol 76, page 564
[19] Divine, page 185

Ministry's role in aircraft development. In The Military Intellectuals in Britain[20], he writes that "official specifications for military aircraft in Britain have all too often lagged behind what designers could produce five years before the type was due to be operational."[21] Higham says that evidence for this statement was to be given in a later work on Production and Politics (which cannot be found). A gem from the Military Intellectuals is that the Hurricane was "Designed to a specification calling for two fixed guns in the fuselage".[22] In truth it was not designed to a specification at all, and had provision for four guns.

In the same author's article on "Quantity vs Quality", the remark is made *vis-a-vis* the lack of a major enemy, that "One result of this in Britain was the dropping of the large bomber from procurement programs for the decade 1922-32 and the concentration on some Home Defence designs, but more on general purpose aircraft."[23] This raises the suspicion that Higham does not understand the RAF's interpretation of home defence, for large bombers were procured for the home defence air force in the period 1922-32, and the RAF did not concentrate on general purpose aircraft, as is demonstrated in chapter 4.

A more recent book by Scot Robertson[24] follows Divine in questioning the competence of the Air Ministry. In a chapter on "Equipment Policy and Aircraft Development", he claims that, "the operational requirements of the peacetime RAF did not call for highly capable aircraft,"[25] and refers to,

> the influence that the RAF's particular strategic theory had upon the perception of operational

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[20] Higham, R., The Military Intellectuals in Britain: 1918-1939, 1966
[21] ibid., page 19
[22] ibid., page 27
[23] Higham, R., "Quantity vs Quality; The Impact of Changing Demand on the British Aircraft Industry, 1900-1960", Business History Review, Vol XLII No.4 page 443
[24] Robertson, Scot, The Development of RAF Strategic Bombing Doctrine, 1919-1939, 1995
[25] ibid., page 65

> requirements. How else can one explain the alarming tendency for the Air Staff to issue specifications for aircraft of such limited performance capability?[26]

He claims that because an admission of the effectiveness of fighters would undermine the theory of the strategic offensive, and with it the independence of the RAF, "they did not fully support research and development in fighter technology."[27] It will be seen that the opposite was the case.

Robertson also accuses the Air Staff of technical incompetence - of not understanding "the complex issue of aircraft development".[28] His own lack of understanding of such issues is encapsulated in the remark that, "The state of technology at the time [1928] was such that performance in one sphere was generally 'bought' at the expense of performance in another."[29] When was this not so? It is precisely the compromise which has to be struck between many individually desirable performance aims which has always dominated aircraft development.

In Robertson's concluding chapter he says that, "Another criticism, *one that is less speculative*, is the tendency in the RAF to issue specifications for general purpose machines for much of the inter-war period."[30] He says that "Research and Development within the RAF and the Air Ministry seemed to aim at the lowest standard commensurate with the RAF's commitments of the time - those being "Air Control" in the Empire."[31] The absurdity of these statements will be evident throughout this thesis.

The examples taken from Smith, Divine, Higham and Robertson of unsubstantiated claims that the Air

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26 ibid., page 65
27 ibid., page 67
28 ibid., page 75
29 ibid., page 70
30 ibid., page 159, italics added
31 ibid., page 160

Ministry's aspirations for aircraft performance lagged behind that which was possible are not uncommon in works on British aircraft development in the inter-war years. They could charitably be attributed to what Edgerton has described as comparison "not with that of other countries, but with an idealised model of technological and industrial development".[32] A less charitable view is that put by Richard Fairey when he considered the possible evolution of the 1929 Supermarine Schneider trophy winner into a fighter, and of a long-range "record breaker" into a bomber. He commented on his conclusions that, "These results may appear rather meagre and disappointing compared with the phantasy that can be conjured up by the imaginative journalist."[33]

Divine, Higham and Robertson have used unsubstantiated versions of Air Ministry policy for aircraft procurement to support criticisms of its competence. They have little to say of positive value to the current research. Smith's account of the development of the RAF and of British air policy up to 1935 has been useful as background, although the prime source used for this purpose is Hyde's British Air Policy between the Wars[34] (recommended in RAF Records at the PRO[35]). Dean's personal account in The RAF in Two World Wars[36] covers the same ground from a different perspective.

1.2.2 RAF Campaign Histories

The literature on RAF operations in the Second World War is relevant to the present research in two respects. First, some authors include a brief history of the aircraft involved in the operations they describe, and it

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[32] Edgerton, D., England and the Aeroplane, 1991, page 19
[33] Fairey, page 576
[34] Hyde, H. Montgomery, British Air Policy between the Wars, 1976
[35] Fowler, S., Elliot, P., Nesbit, R.C., Goulter, C., RAF Records at the PRO, 1994
[36] Dean, Sir Maurice, The RAF in Two World Wars, 1979

is of interest to see how these compare with that found in the current research. Second, one purpose of the current research is to contrast the operations which the RAF encountered early in the Second World War with those that had been anticipated in the requirements it stipulated for its aircraft. For this latter purpose the literature has been useful, but many descriptions of aircraft development are inadequately researched.

Descriptions of the development of the fighter aircraft in service in 1939 often begin with the supposed origin of the Hawker Hurricane and Supermarine Spitfire in 1934. Wood and Dempster,[37] Terraine,[38] and Richards,[39] are examples. In chapters 5 and 6 it will be shown that such descriptions are contradictory and at variance with Air Ministry proposals and actions at the time.

Terraine provides an example of the errors which can arise from dating aircraft development from an apparently relevant specification. In listing the achievements of Sir Edward Ellington, Chief of the Air Staff from 1933-37, he identifies specification F.5/34 as leading to the Hurricane and Spitfire,[40] which, as will be shown, was not so. Moreover, far from Ellington deserving credit for F.5/34, he caused its postponement in favour of his own amazing idea for a multi-turret fighter, discussed in chapter 6.3.

Terraine also joins many authors (as discussed in chapter 6) in accusing senior officers of resisting the move towards increased firepower, in which the eight-gun fighters were an important step. Yet, as will be shown, this need and steps to implement it were initiated by senior officers (Trenchard included) as early as 1927.

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[37] Wood, D. and Dempster, D., The Narrow Margin, 1961
[38] Terraine, J., The Right of the Line, 1988,
[39] Richards, D., Royal Air Force 1939-45, Vol I, 1974,
[40] Terraine, page 16

As regards the origin of the bombers operated in the war, it is often assumed in the literature that, as the RAF adopted a night bombing offensive, its bombers were planned for that purpose. That this was not so is shown in chapters 8 and 9.

1.2.3 Specific Aircraft Types

Much of the literature on individual aircraft types is primarily concerned with their wartime operations, and has nothing significant to say about the operational requirements the aircraft were originally designed to fulfil. But some writers purport to give the history of development of the eponymous aircraft as well as its operational record. A common problem is that they do not go beyond, and in many cases not even to, Air Ministry specifications, despite claims to the contrary. They pick up the story they tell without having seen the first two or three chapters - but knowing the conclusion.

Many examples of this omission are noted in later chapters. Perhaps its most extreme form is the recently published <u>The British Aircraft Specifications File 1920-49</u>, which purports to give a summary of all specifications in that period. Yet the authors, Meekoms and Morgan, claim that, "access to detailed copies of British aircraft specifications prior to 1936 is a rare event."[41] In fact these documents, and many related Air Ministry papers, are readily available. They are the primary sources on which this thesis is based.

Meekoms and Morgan say that their data is based upon the Putnam series of publications which cover the aircraft produced by individual firms. These may be accurate in their physical descriptions of aircraft produced, but, as

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41 Meekoms, K.J. & Morgan, E.B., <u>The British Aircraft Specifications File 1920-49</u>, 1994, page 7

will be shown, some are unreliable in their references to Air Ministry policy and to specifications. The same comment applies to F.K. Mason's The British Fighter[42] and The British Bomber[43].

There are exceptions to the above general comments on specialist books. Price's[44] study of the evolution of the Spitfire from the seminal specification F.7/30, through the Supermarine Type 224 to the last Griffon engined Marks, deals comprehensively with the early stages of development. His research refutes the oft expressed view that the Spitfire was a private venture by Vickers Supermarine. Yet the biography of R.J. Mitchell, edited by Mitchell's son, makes the claim that development from the Vickers Supermarine Type 224 to the Spitfire was funded by the company, even though the writer was aware of Price's work, and corresponded with him over the question of the date of the first flight of the Spitfire.[45] But then G. Mitchell also joins many others whose research failed to pick up the fact that F.7/30 was issued in October 1931, and not in 1930.

A reliable publication on RAF bomber development during the 1930s is Goulding and Moyes' Bomber Command and its Aircraft 1936-40.[46] Their account does not deal with some early stages in Air Ministry thinking, and is not referenced, but it is very largely confirmed by the primary sources on which this thesis is based. The Air Historical Branch Narrative on the Pre-War Evolution of Bomber Command[47] also covers this subject. It is referenced to Air Ministry papers, which, although not directly traceable from these references, are those used in later chapters of this thesis.

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42 Mason, F.K., The British Fighter since 1912, 1992
43 Mason, F.K., The British Bomber since 1914, 1994
44 Price, A., The Spitfire Story, 1992, (first published 1982)
45 Mitchell, G., R.J.Mitchell, 1986, page 132
46 Goulding, J. and Moyes, P., Bomber Command and its Aircraft 1936-40, 1975
47 PRO: AIR 41/39, The RAF in the Bombing Offensive against Germany, Vol 1 Pre-War Evolution of Bomber Command

It is likely that a prime source of misrepresentations of Air Ministry aircraft development policy - of which further examples are given in later chapters - is the Official History of the Design and Development of Weapons,[48] which was published before Air Ministry files were open to the public. It has been noted above that the authors of that volume took the view that the formulation of operational requirements, "need not delay us long". It may be this neglect which has led to some remarkably incorrect accounts of the origin of many well-known aircraft, both by Postan *et al* and other writers. In later chapters these are contrasted with the actual events of the time.

1.2.4 Technical Background

An important feature of the current research is to relate the RAF's assessment of its operational requirements to those which it was technically feasible to meet at the time, and to note the impact of advances in aviation technology on the RAF's perception of how air warfare would develop. In pursuance of these issues reference has been made to a number of works on aviation technology.

For general technical background Price's Fighter Aircraft[49] and Bomber Aircraft[50] give an excellent review of the state-of-the-art of aircraft design at the beginning of the War in 1939 and of developments thereafter.

Modern academic textbooks on aviation science and engineering include advances which were not available to the Air Ministry and aircraft designers in the 1920s and 1930s. To avoid a critique based upon such hindsight the

48 Postan, Hay and Scott
49 Price, A., Fighter Aircraft, 1989
50 Price, A., Bomber Aircraft, 1989

author has sought standard works of those times. However, it would be unwise to assume that Air Ministry staff (particularly serving officers) and the aircraft industry's design teams were fully aware of the advances in theory that were then taking place, or indeed that these were of much direct use to practical designers.

Von Mises' Theory of Flight[51] is a much respected textbook. It was first published in English in 1945, but was derived from his earlier publications in the mid-1930s and his many years of lecturing on the subject. It contains a section on "Historical Notes" which briefly describes and dates the origins of the understanding of airflow and the development of mathematical formulations aimed at calculating the aerodynamic loads on an aircraft which were known at that time. Anderson's recent A History of Aerodynamics and Its Impact on Flying Machines[52] covers this subject in detail up to the present time. Although great advances were made between the wars, these did not this succeed in producing direct design tools - these had to await the use of the techniques of numerical analysis coupled with the power of modern computers.

On the other hand aircraft performance calculations, based upon estimated or measured aerodynamic loads, presented a much simpler problem. Von Mises notes that the first competent applications appeared in the years immediately preceding the 1914-18 war. The state-of-the-art at the end of that war is given by Bairstow.[53] My bibliography includes some books on aircraft performance calculations published in the 1920s and 1930s, but these were attempts to simplify the calculations and did not add to the already well-established theory. They may well illustrate the methods used in the Air Ministry in their analysis of the potential performance of aircraft projects.

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[51] von Mises, R., Theory of Flight, 1959

[52] Anderson, J.D., A History of Aerodynamics and Its Impact on Flying Machines, 1997

[53] Bairstow, L., Applied Aerodynamics, 1920

1.3 SOURCES

Since the aim is to establish an authoritative account of the RAF's perception of the home defence aircraft it needed in the 1920s and 1930s, it is not surprising that the major primary sources were found at the Public Record Office, Kew (PRO). It is there that many of the working papers of the Air Ministry are archived. In the AIR classes there are papers covering the exposition of the Air Staff's policy views on the use of air power, the discussions which led to the setting of operational requirements, and the translation of these into the specification of particular aircraft types. Surprisingly, and regrettably, the Indexes do not have an entry 'Operational Requirements', even though this jargon was in use in the Air Ministry in the 1920s, and in 1934 a section of the Air Staff was established with that title. This was later upgraded to a Directorate, and from 1934 there was an Air Ministry Operational Requirements Committee.

Papers on a particular aircraft's "Type Requirements" are relatively easy to find, and these usually include the relevant specification, but background information on the thinking which preceded the specification stage of development, or which did not lead to a specification, has required much reading of files with superficially unpromising titles scattered amongst many AIR classes.

The Public Record Office guide to documents pertaining to the Second World War[54] describes class AIR 2 as containing the "registered correspondence of the Air Ministry, covering the whole range of British air administration and related topics". Complementary unregistered files are in class AIR 20. These two classes have proved to be a

[54] Cantwell, J.D., The Second World War, 1993

valuable source of information for the present research. It is AIR 2 which contains Type Requirements files from the mid-1920s onwards.

PRO class AIR 5 is not included in the guide to the Second World War, no doubt because it is mainly a selection of older papers; it is referred to briefly in RAF Records at the PRO.[55] Nevertheless, it has been a useful source for the current research, with a number of important files on the business of the Air Fighting and Bombing Committees. Class AIR 6, "Records of Meetings of the Air Board and Air Council" has provided material on some aspects of the development of policy and of War Plans.

Classes AIR 8 and AIR 9 are said to contain the papers of the Chief of the Air Staff and of the Director of Plans respectively. The former contains useful background material, and the CAS's copies of papers which may also appear elsewhere. For the inter-war years AIR 9 covers much more than is indicated by the PRO's guide ("strategic and operational planning records"). For much of that period there was no post of Director of Plans; "Plans" came within the Directorate of Operations and Intelligence, and AIR 9 contains many files on policy with respect to aircraft, on type requirements, and some Minutes of the Operational Requirements Committee.

Other PRO AIR classes which have provided material are AIR 10 (publications), AIR 14 (Bomber Command), AIR 16 (Fighter Command, and some pre-1936 papers of Air Defence of Great Britain Command). AIR 41 contains the Air Historical Branch, Ministry of Defence, narratives on the RAF in the Second World War.

The PRO's AVIA class contains files of the Ministry of Aircraft Production which was set up in May 1940. Some of

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[55] Fowler *et al*

these include material dated before the formation of MAP, particularly the papers of Sir Wilfred Freeman.

A number of other collections of relevant material have been consulted. The Air Historical Branch of the Ministry of Defence has copies of most aircraft specifications issued since 1930 - useful for filling some gaps in the records held by the PRO. The libraries of the Institute of Historical Research and of the Royal Aeronautical Society have collections of reference and of secondary material which have been valuable. The RAeS Library has an extensive collection of works on aircraft and aviation history, with books, pamphlets and manuals, its own and other journals, dating back to the early years of aviation. Of particular value has been its comprehensive stock of "enthusiasts" books, which although often of doubtful accuracy on matters of Air Ministry policy have provided pointers to aircraft which were built, both British and foreign, and to their operational history.

Secondary sources have been used for the political and strategic background to this study of the development of the RAF's operational requirements, but as explained in section 1.2 above and further illustrated in later chapters, they are of doubtful value on that subject itself.

1.4 SUMMARY OF CHAPTERS

The RAF's assessment of the aircraft characteristics it required was heavily influenced by the development of its doctrine of air warfare in the early 1920s. This period also saw the establishment of concepts of direct defence against air attack which had a lasting influence on assessments of the tactical role and potential of fighters. These issues, together with other relevant political, strategic and technological events of the 1920s and 1930s, are reviewed in chapter 2.

Chapter 3 outlines the organisation of the Air Ministry in relation to responsibility for operational requirements and specifications. It describes the procedure for the initiation and evaluation of new types of aircraft, and the slow and uncertain evolution of an administrative system for managing the formulation of operational requirements. It explains how the somewhat double-headed system of the 1920s, whereby the Air Staff's views could be superseded by the Air Member for Supply and Research's control of the annual Experimental Aircraft Programme, was resolved in 1933-34; the first steps being the establishment of an Operational Requirements Committee and an Operational Requirements section in the Air Staff.

The core of the research is chapters 4 to 9. The treatment is chronological, for this brings out both the evolution of thinking and the correct sequence of events - vital to an understanding of the beginnings of each aircraft type.

The development of operational requirements from 1922 to 1930 is discussed in chapter 4. It was in this period that the first steps were taken to implement the RAF's doctrine of home defence through the specification of the aircraft types required. It is shown that in the late 1920s some developments were initiated which had an important influence on the key decisions of the early 1930s.

Chapters 5, 6, 7 and 8 deal in depth with the development of operational requirements in the years 1930 to 1936. It was in those years that most of the aircraft with which the RAF fought the Second World War were initiated. It is shown how the Air Ministry responded both to emerging technical developments and to a fundamental shift in the prospect of war and in the potential enemy.

The policies and decisions which led to the Hurricane and Spitfire are discussed in chapter 5, where it is shown that there was a significant move to make maximum speed the prime requirement of RAF fighters. This requirement that was met through the Ministry's high-speed research aircraft programme, which was a follow up to the Schneider Trophy successes of 1927-31. Chapter 6 discusses fighter armament development, both for the eight-gun fighters and for the little known projects which culminated in the Defiant.

Bomber development in the early to mid-1930s is discussed in chapters 7 and 8. France was seen as the potential enemy in the earlier years, and it was this which conditioned the operational requirements which led to the Battle, Wellington and Hampden. When Germany was recognised as a threat the range and speed sought for bombers increased. This process is first traced through the development of operational requirements for the Whitley and Warwick, and then, in chapter 8, to its full exposition in the 1936 requirements which led to the Stirling, Halifax, Manchester - and ultimately the Lancaster.

Chapter 9 looks at the development of operational requirements in the years immediately preceding the outbreak of war. This was a time of rapid expansion of the RAF, and of the Air Staff's Operational Requirements organisation, yet little emerged that was not overtaken by later wartime expediency. The only new type that evolved in those years and which served in its intended home defence role was the Mosquito.

Chapter 10, Conclusions, reviews the operational experience of the aircraft which had been defined in the early and mid-1930s from the point of view of their role and achievements as compared with that envisaged earlier. It is well known that many expectations were proved wrong, and the chapter concludes with a brief consideration of the operational requirements that might have been specified had the key assumption which under underlay RAF strategy - the viability of self-defending formations of day bombers - not been made.

2. POLITICAL AND STRATEGIC BACKGROUND

Operational requirements were formulated by the Air Ministry as part of its response to the duties placed upon it by the Government, and thus necessarily took account of the national and international political situation which faced the Government. The first part of this chapter outlines those events which were of some significance to the RAF's specification of operational requirements. They were the fears of French air power which arose in 1922 - which both preserved and re-vitalised the RAF, the opening of the possibility of war through the Japanese invasion of Manchuria in 1931, the Geneva Disarmament Conference 1932-34, and the emergence of Germany as a threat from 1933-34. These events had a general, and sometimes specific, influence on the Air Staff's view of the operational capability it sought from its aircraft. Their impact is briefly mentioned below, and discussed in detail as appropriate in the following chapters.

The converse to the influence of political affairs on the operational requirements of the RAF was the influence on politics of the military potential of developments in aviation. The Air Staff's advice to Government on the scale of unpreventable air attack on London, and on the catastrophic effect it would have, was a major component of the background to British European policy in the 1920s and 1930s. In the course of discussions on the "Continental Air Menace" in 1922, Lord Balfour commented that,

> Day after day, night after night, the capital of the Empire would be subject to an unremitting bombardment of a kind which no city effectively acting as the military, naval and administrative centre of a country engaged in a life and death struggle, has ever had to endure.[1]

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[1] PRO: AIR 9/69, Folio 13, Extracts from papers in which the CAS stressed priority of the air menace over all other defence problems; Note by Lord Balfour, 29th May 1922

The second part of this chapter describes and discusses the doctrine of air warfare which was adopted to combat this fear, and the RAF's interpretation of that doctrine into a strategy for home defence against air attack.

2.1 POLITICAL CONTEXT

The political issue of most concern to the RAF in the early 1920s was the long-running battle over the existence of a separate air force. Hyde[2] and Dean[3] have described the political and military manoeuvring whereby the Army and Navy sought, unsuccessfully, to gain control of British air forces.

The political event in the 1920s of most relevance to the current research was the worsening of diplomatic relations with France in 1922. Concern over the size of the French Air Force led to the decision to strengthen the RAF, for it had been much reduced in size after the end of the 1914-18 war. There followed two Home Defence Expansion Schemes. That of 1922 for twenty-three squadrons was soon superseded by the better known 1923 Scheme for fifty-two squadrons.[4] The analysis of the role of the RAF initiated by these expansion schemes went far to determine the characteristics of the aircraft which the RAF sought for many years.

The fifty-two squadron Scheme followed from the deliberations of a Sub-Committee of the Committee of Imperial Defence chaired by Lord Salisbury. The Salisbury Committee's terms of reference were to inquire into the co-operation and correlation between the Army, Navy and Air Force, and *inter alia*, into "the standard to be aimed at for defining the strength of the Air Force for purposes

[2] Hyde, Chapter II

[3] Dean, pages 33-37

[4] PRO: AIR 5/955, Home Defence Expansion Scheme of the Royal Air Force, 1922-1923

of home and imperial defence."[5] The Committee issued an interim report in June 1923 which included the recommendation that,

> British air must include a Home Defence Air Force of sufficient strength adequately to protect us against air attack by the strongest air force within striking distance of this country.[6]

The Salisbury Committee's recommendations were endorsed by the Cabinet, and in June 1923 a statement was made to Parliament that "In the first instance the Home Defence Force should consist of 52 squadrons".[7] This number was explained in a Committee of Imperial Defence paper which set out the Provisional Home Defence Scheme. It stated that, "The object is to attain, and maintain, approximate numerical equality with the French Independent Striking Force."[8] The Air Staff was to explain that,

> At the present time France is the only power which maintains a powerful air force within striking distance of Great Britain.
> The estimated potentiality of the French air force, therefore, is used as a basis for calculating the air defence measures necessary for this country.[9]

It will be seen that this consideration shaped the Air Staff's views on operational requirements, and on airfield location, long after any thought that war with France was conceivable, because some basis for defence planning was required. The air force of the United States also had a problem in deciding what conflict to plan for, and also chose what in retrospect seems a most unlikely scenario. Greer says that, "The usual enemies postulated were a

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[5] Hyde, page 119
[6] ibid., page 134
[7] ibid., page 136
[8] PRO: AIR 8/73, Progress of the Home Defence Expansion Scheme, Item 1, C.I.D. 120-A, 3rd November 1923, Provisional Scheme for the Expansion of the Royal Air Force for Home Defence, Appendix A, section 1
[9] 9/69 Folio 24, Air Staff Memorandum on Air Attack on Great Britain, Part I Scale of Attack, 28th May 1924, para.1

coalition of European powers headed by Great Britain, possibly in combination with Japan."[10]

The planned strategy for the fifty-two squadron force and its composition are discussed later in this chapter. It was specifically for home defence. The RAF had other duties and additional squadrons to fulfil them. The "First Report on War Organisation", prepared in 1934, listed the RAF's commitments as:

A minor emergency overseas
A war in the Far East
Defence of India
Home Defence and Locarno[11]

Only the fourth item could involve the question of home defence, but it was this which was the first priority[12] and predominant in the assessment of the operational requirements which the RAF specified for its aircraft.

Contrary to the claims of some writers, "Air Control" operations in Iraq and on the North West frontier of India had no influence on aircraft performance requirements for home defence. This point is discussed in chapter 4. Such operations may have encouraged belief in the effectiveness of air power, although as will be seen, the RAF needed no encouragement in that direction.

2.1.1 The Years of Expectation of Peace

In 1923 the intention was to complete the Home Defence Scheme within five years, and there was no change in this intention when Labour replaced the Conservatives in Government late in 1923.[13] However in 1925, when the Conservative party had returned to power, the Government

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[10] Greer, T.H., The Development of Air Doctrine in the Army Air Arm, 1917-1941, 1955, page 30
[11] PRO: AIR 6/22, Air Council Precis No. 565, 22nd October 1934, para. 1
[12] ibid., para. 67
[13] Hyde, page 152

believed that the international situation had improved following the admission of Germany to the League of Nations, and the pending signature of the Treaty of Locarno. Completion of the fifty-two squadron scheme was deferred to 1935-36 following a Cabinet committee investigation chaired by Lord Birkenhead.[14] When a Labour Government was formed again, in 1929, completion was put back to 1938.[15]

These postponements reflected the general policy of curtailment of defence expenditure, best known through the so-called ten-year rule. British military planning was to be based upon the assumption of no major war in the next ten years, a policy first stated in 1919, re-affirmed in 1922, and continued until 1932.[16] One consequence of financial restrictions was a preference to equip the RAF with old rather than new designs, and small rather than large aircraft. This was well illustrated by the Director of Equipment in 1925. He wrote that,

> for slightly less than the price of one of the new Single engine day Bombers complete with Condor engine, or one Fairey "Fawn" with a Lion, we can purchase and put into service three new D.H.9.A's, and for one "Virginia" complete with 2 Lions, seven D.H.9.A's.[17]

A major impact on operational requirements was the decision that separate fighter squadrons for day and night defence could not be afforded. As a result nearly all fighter requirements demanded a low landing-speed for safe operation at night, and the carrying of equipment for night flying.[18] It will be shown that these requirements inhibited attainment of the highest contemporary performance for day defence.

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[14] ibid., page 179
[15] ibid., page 217
[16] ibid., page 59
[17] PRO: AIR 2/302/S25726, Replacement of D.H.9.A, DoE to AMSR, 21.7.25
[18] PRO: AIR 2/1069, Conditions Governing the Design of a Home Defence Fighter Aeroplane, 1A, 6.3.23

Throughout the 1920s and early 1930s the British Government's policy was to seek security through International agreement *via* the League of Nations. Disarmament talks during this period included proposals to abolish or limit bombing from aircraft, and these efforts continued through to the Geneva Disarmament Conference of 1932-34.[19] In chapters 7 and 8 it will be shown that they had an important influence on the development of RAF bombers.

2.1.2 War on the Horizon

The Japanese invasion of Manchuria in 1931, and the failure of the League of Nations to respond forcefully, re-opened the possibility of war.[20] It aroused concern about the security of British possessions in the Far East, particularly of Hong Kong and Singapore, and brought the end of the ten-year rule. Recognition of the need to rapidly reinforce the Air Force in the Far East led the Air Staff to introduce the concept of reinforcement range into its operational requirements for bombers.

The emergence of Germany as a military threat in 1933-34 led to a major re-alignment of Air Staff planning in many respects. Prior to 1934 the RAF's operational squadrons had been disposed to counter an air attack from France. In August 1934 the Air Ministry was instructed to prepare a plan for the Air Defence of Great Britain on the assumption of war with Germany, with France as an ally. The plan was to include the possibility that German aircraft would overfly Holland and Belgium, or occupy airfields in those countries.[21]

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[19] Dean, page 41

[20] Roberts, J.M., Europe 1980-1945, 1989, page 506

[21] PRO: AIR 2/1386, Sub-committee of H.D.C. on Re-orientation of Home Defence System, 2nd August 1934

Germany as the potential enemy meant that attacks were now to be expected from the East rather from the South, with consequent re-orientation of the RAF's fighter defence system. Needless to say, a direct effect of considering Germany rather than France as the potential enemy was greatly to increase the operational range required of bombers, and in consequence their size. This aspect is discussed in chapters 8 and 9.

2.1.3 Re-Armament

The Government's reaction to the emergence of a German air force was to restate the 1923 policy of parity, but with respect to the German air force rather than the French.[22] The Air Staff became concerned that the Government saw parity in terms of numbers of aircraft, whereas they believed that it should take account of the relatively high vulnerability of the position of London, and should compare opposing air forces in terms of the bomb tonnage deliverable per day.[23] This latter consideration was to dominate Air Staff bomber policy in the late 1930s.

The much-deferred fifty-two squadron Home Defence Expansion Scheme of 1923 was replaced by a sixty-nine squadron scheme in 1934. Then, as reports indicated that the strength of the German air force was planned to increase, so was the planned size of the RAF.

Scheme L, approved in November 1938, included a significant change in the ratio of bombers to fighters, with fifty-seven bomber squadrons and forty fighter squadrons.[24] This reflected the recommendations of Sir Thomas Inskip, Minister for the Co-ordination of Defence. In a review of the basic principles of British war policy against Germany he concluded that direct defence against

[22] Hyde, page 339

[23] 9/8 Folio 52, DDPlans to DCAS, 24.9.36

[24] Hyde, Appendix VII

air attack was the better strategy for the early stages of such a war. The Cabinet imposed this policy on the RAF.[25] No evidence has been found to suggest that it influenced the RAF's assessment of the aircraft types it needed. The RAF was uncertain as to whether advances in aviation technology favoured fighters or bombers, but nevertheless maintained its belief that a counter-offensive policy offered the best defence.[26]

In 1935 the Italian invasion of Abyssinia raised the prospect of war in the Mediterranean. This further emphasised the need to pay attention to the reinforcing range of RAF aircraft, but otherwise gave no experience of air fighting. The Spanish Civil War, 1936-1939, did include air fighting. Initially both Republicans and Nationalists used obsolescent aircraft with little effect, but later Russia, Italy and Germany supplied and operated some of the best contemporary aircraft. For the first time since the 1914-1918 war there was some evidence of the strategic and tactical effectiveness of high-performance aircraft.[27,28] This was not unnoticed by RAF officers, but did not lead to any change in aircraft development policy.

Against the above background of political developments, the RAF pursued the doctrine that a counter-offensive was the best, indeed only, way to deter or diminish air attacks on London. The following section discusses that policy and its application in detail to the composition of the home defence air force and its equipment.

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25 ibid., page 412

26 PRO: AIR 8/243, The Role of the Air Force in National Defence, November 1938

27 Jackson, R., Fighter: The story of Air Combat, 1979, chapter 1

28 Corum, J.S., "The Luftwaffe and the Coalition Air War in Spain 1936-1939", JSS, Vol 18 (1995), No.1, page 68

2.2. DOCTRINE AND STRATEGY

It has been seen the major task of the RAF was the defence of the United Kingdom against air attack. The logical steps which were needed to carry out this task were the determination of an overall doctrine, the assessment of the balance of the force needed to implement that doctrine against potential enemies, and the definition of the equipment required. These issues are discussed below.

2.2.1 Doctrine

The tenet which governed the British concept of air warfare was that there was no effective direct defence against air attack on London. From this it followed that the only way to deter or diminish the bombing of London was to plan to attack an enemy's country. It was this doctrine which determined both the offensive/defensive balance of the RAF and the performance it sought from its aircraft and armament. It was not disputed by Government, for, as illustrated by Powers[29] and Bialer[30], the fear that devastating attacks from the air were possible and unstoppable had become widely accepted in the 1920s. Charlton's essay published in 1938 is an example of the popularisation of this view.[31] That this fear was the basis of British air policy was exemplified by Baldwin's much quoted statement to the House of Commons in November 1932. He said,

> I think it is well for the man in the street to realise that there is no power on earth that can prevent him from being bombed. Whatever people may tell him, the bomber will always get through. The only defence is offence, which means you have to kill more women and children more quickly than the enemy if you want to save yourselves.[32]

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[29] Powers, B.D. Strategy without Slide-Rule, 1976, Chapter 5

[30] Bialer, Uri, The Shadow of the Bomber, 1980, page 47

[31] Charlton, L.E.O., The Air Defence of Great Britain, "The New Factor in Warfare", 1938

[32] Dean, cited on page 59

Powers sees this as "the awesome dilemma of the English, given their prevailing axioms about air power".[33]

The British concept of the future development of air warfare was not unique. It was similar to the views promulgated by the Italian General Douhet,[34] who is often quoted as the first proponent of the offensive as the only effective course of action in air warfare. It was strongly supported in the United States.[35,36]

In August 1923 (with a supplement in March 1924) the Air Staff issued a memorandum on "Air Strategy in Home Defence. The correct objective". It stated that, "the main objective for an air force lies in the aircraft factories and productive centres of the enemy's country, his seat of government and his supply and transport system".[37] Not only did it believe that these objectives should take precedence over attacks on the enemy's air force, but that to achieve the maximum offensive power,

> it may be stated as a principle that bombing squadrons should be as numerous as possible and the fighters as few as popular opinion and the necessity for defending vital objectives will permit.[38]

This policy was advocated by the RAF thereafter. It believed that its choice of objectives would, "have the greatest possible effect on the true objective of all war - the morale of the enemy nation."[39] But emphasised that such a strategy was applicable to "'air warfare' only; that is to say war between two nations who have no land frontiers in common", and where seaborne invasion was not feasible.[40]

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[33] Powers, page 153
[34] Douhet, Giulio, <u>The Command of the Air</u>, 1921 (English translation published 1943)
[35] Greer, page 44
[36] Freeman, R., <u>The U.S. Strategic Bomber</u>, 1975, pages 18 and 21
[37] PRO: AIR 8/71, ASM 11, section 4
[38] ibid., 11.A. (To be read in conjunction with A.S.M No.11), March 1924, section 3
[39] ibid., ASM 11, section 4
[40] ibid., ASM 11.A, section 2

Powers suggests that the RAF's adoption of the doctrine of strategic bombing as the basis of home defence from air attack was a way of emphasising the need for a separate air force, but he notes that this policy was "also the one most in accord with the current public image of air power".[41]

Douhet foresaw the need to obtain command of the air space over an enemy's territory, envisaging that this would be achieved by forcing the enemy's air force to battle in defence of its ground installations, and of its cities. M. Smith summarises Douhet's "great and unique" contribution as being his emphasis on the need to gain command of the air and then to exploit that command when won. Smith contrasts this with RAF policy. He claims that,

> In particular, the British school of air power never understood the classical concept of 'command of the air', and they came to rely instead on what was considered the unique power of the bomber to prepare the way for victory, virtually by ignoring the existence of the enemy air force as a strategic obstacle.[42]

But it was not that the RAF did not understand the concept of command of the air, rather that they did not regard it as necessary, nor attainable.[43] The Air Staff argued that an enemy air force did not need to be overcome before its homeland could be attacked, and that in any case an air force could not be permanently overcome by other air forces. In the terminology defined by Howard,[44] the Air Staff believed that air power could be "exercised" without the need for "command" of an enemy's air space.[45]

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[41] Powers, page 166
[42] Smith, M., page 45-46
[43] 9/69, Folio 54, The Defence of England against Air Attack, lecture by DCAS to Naval Staff College, 10th March 1924, page 7 Air Superiority
[44] Howard, M, "The Concept of Air Power - an historical appraisal", Air Power History, Vol 42 (1995) No.4, pages 4-11
[45] 8/71, ASM 11.A, section 2

2.2.2 Feasibility of the RAF's Doctrine

Between the wars the Air Staff held firm views about the feasibility of its counter-offensive strategy. It was based upon four assumptions which would need to be correct for the strategy to be valid.

(i) that accurate bombing was possible,
(ii) that it would be effective,
(iii) that it could be carried out by self-defending formations of bombers,
(iv) that continuous, day and night, bombing was essential and possible.

The Air Staff's confidence in the accuracy and effectiveness of bombing and in the viability of self-defending bomber formations was not based upon evidence from the Great War. The Independent Air Force's bombing had then not proved to be very effective, and its losses were high. Morrow says that, "Battle casualties to day-bomber units in five months amounted to 257 aircrew, 178 per cent of its force strength in November (1918), while its monthly wastage rate was just under 70 per cent".[46]

In 1923 the RAF had no evidence of accurate bombing, and was to base its views on the effectiveness of bombing on the limited experience of German air attacks on Britain during the 1914-18 war.[47] Expectations of accuracy were based upon peacetime trials, but no live trials on the effect of bombing against typical targets were made between the wars.[48]

An example of the Air Staff's views on the accuracy of bombing was given by the CAS, Sir John Salmond, in his

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[46] Morrow, J.H. Jnr., The Great War in the Air, 1993, page 321
[47] 9/69 Folio 91, Bombing Casualties Among the Civilian Population, undated and unsigned
[48] MacBean, J.A. and Hogben, A.S., Bombs Gone, the development and use of British air-dropped weapons from 1912 to the present day, 1990, Chapter 2

address to the Committee of Experts on Fighting Services of the 1930 Imperial Conference. In dealing at length with the potential of aircraft for coast defence, he cited recent trials in which 18% hits on ships were obtained from high-altitude bombing and 80% from low altitude. He also stated that torpedo trials in all the previous year's practices had averaged 45% hits.[49] Indeed, such was the accuracy expected of bombing that the Air Staff feared that attacks in squadron formation could be wasteful. Thus when considering the best size for Sidestrand squadrons in 1933, Plans branch advised that, "If the bombing becomes so accurate that bombs are wasted owing to the width of the squadron formation I presume it is always possible to bomb by flights in line ahead and thus reduce the width of the pattern."[50]

An example of the assumed effectiveness of bombing arose in 1925, when the Air Staff's estimate of the scale of attack which could be mounted against London by France was questioned by the War Office. They replied that, "the Air Staff would point out that it matters little whether 100 or 200 tons are dropped per day. The effect would still be overwhelming in either case."[51] This conclusion was reinforced in 1936 when an assessment of the likely scale of a German air attack on London, and its effects, was made.[52] Group Captain A.T. Harris was one of the authors. It was estimated that if 100 tons of bombs were dropped on the first day, 75 tons on the second day and 50 tons for each of the next four days, then the Underground and mainline stations would be out of action, and all gas supplies and 50% of electricity supplies would be lost. In this assessment it was assumed that 75% of the raids

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[49] PRO: AIR 8/115, Imperial Conference 1930, Item 12,

[50] PRO: AIR 20/84, Day Bomber Design Consideration of Aeroplanes and Equipment, Plans to DDOI, 11.4.33

[51] 9/69 Folio 34, Air Raid Precautions, note by the Air Staff, 25th October 1925, para.8

[52] PRO: AIR 41/14, The A.D.G.B. Vol.1 The Growth of Fighter Command, Appendix 6, Air Attack on Great Britain, Annexure B, Summary of Estimates of Effect of Air Attack on London, 26th October 1936

were by day and 25% by night, and that poison gas would not be used.

The third plank of the RAF's doctrine, belief in the ability of bombers to defend themselves against defending fighters, will be a recurring theme. It was based upon the view that,

> the defensive fire of the bombing formations (which is very effective if the drill and equipment are good) must be relied upon to enable them to carry out their task.[53]

A demonstration of the Air Staff's belief in the ability of bomber formations to defend themselves appeared in a note to the Admiralty in 1928. Advice had been sought on the likely outcome of an engagement between aircraft. The Air Staff's reply was based upon Lanchester's N^2 rule for calculating the outcome of engagements.[54] Lanchester deduced that "The *fighting strength* of a force may be broadly defined as proportional to *the square of its numerical strength multiplied by the fighting value of its individual units.*"[55] The Air Staff said that experience and study showed that the fighting value of a good formation of bombers was far higher than that of the same number of single-seat fighters, and took the fighting value of a bomber as twice that of a fighter. Not surprisingly, bombers came out of the calculations of combat with fighters rather well.

Even in 1938, when the development of eight-gun fighters and radar gave some hope that effective defence was possible, the Air Staff retained its belief in the accuracy, effectiveness and feasibility of bombing. When arguing the case for a large bomb load for its "Ideal Bomber", it said that,

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[53] 8/71 ASM 11.A, section 3

[54] PRO: AIR 8/98, Actions between Aircraft (April 1928)

[55] Lanchester, F.W., Aircraft in Warfare, 1995, (first published in 1916), page 55, italics in original

> one sortie may attack two different objectives en route to its main objective, and two more on the way back, say five different targets in one sortie - in other words, one large aeroplane might be the equivalent either of a formation of smaller ones attacking the same target, or a number of single smaller ones attacking different targets.[56]

Given the firmly held views on the capability of the RAF's bombers which have been illustrated above, it is not surprising that it was believed that an enemy's bombers could not be prevented from reaching and destroying London. Nevertheless, it was accepted that some fighter squadrons were needed, even if, as Dean wrote, they were "mainly to propitiate weak-kneed politicians and civilians".[57] The Air Staff gave a more military justification in 1924. It accepted that without some fighter defence, "a well organised commercial aviation company might be as efficient as a highly trained bombing group".[58]

The general principles for defence against air attack described above were put into effect when fears arose about the size of the French air force.

2.3 THE 1923 HOME DEFENCE SCHEME

The strategy for defence against air attack was considered by a Sub-committee appointed by the "Joint War Office and Air Ministry Committee on Air Defence of Great Britain". The Sub-committee was chaired by Air Commodore J.M. Steel, and the senior War Office member was Colonel W.H. Bartholomew. It is commonly referred to as the Steel-Bartholomew committee. It reported in February 1923 that,

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[56] PRO: AIR 9/82, The Ideal Bomber, 19A, Considerations Affecting the Design of the Ideal Bomber Aircraft for the Royal Air Force, Air Staff, March 1938, section 18 (iv)
[57] Dean, page 40
[58] 9/69 Item 56, Reasons for having Fighting Squadrons and Ground Defence in the Home Defence Scheme, Air Staff, 8.3.24, para.4

> The Sub-Committee recognise that offensive action by aircraft in the enemy's country is the best form of defence but that a defensive system, combined with an active offensive, is a necessity.

It proposed that such fighters as were provided should be stationed sufficiently far inland to have time to climb to intercept hostile aircraft after they had been detected crossing the coast, and it coupled this with the need for a good intelligence and plotting system.[59] These views on the best strategy for direct defence were not new. They had been discussed by the A.A. Committee in 1921,[60] and as will be seen, had their roots in the reaction to German air attacks on London in 1917-18.

During July and August 1923 the Chief of the Air Staff, ACM Sir Hugh Trenchard, held a series of meetings with senior RAF officers to discuss the composition of the home defence air force.[61] These took place against the background of the recommendations of the Steel-Bartholomew committee[62] (which had been agreed by the Committee of Imperial Defence), and the decision that the strength of the force should be fifty-two squadrons.

The meetings considered the number of bomber and fighter squadrons, day and night bombing, day and night defence, and the location of squadrons. These discussions, and the ensuing decisions taken by Trenchard,[63] went far to determine the types of aircraft which would equip the RAF up to the outbreak of the Second World War, and their relative performance characteristics. They are discussed below.

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59 9/69 Folio 51, Steel-Bartholomew Committee Report, February 1923, section 3

60 PRO: AIR 5/564, Papers and Conferences re Air Menace, Minutes of 2nd meeting, 11th October 1921

61 PRO: AIR 2/1267, The Expansion of R.A.F for Home Defence Purposes. Policy

62 PRO: AIR 5/416, Position of the Relative Numbers of Fighters & Bombers Required for Home Defence, Minutes of 25th July 1923

63 ibid., CAS to DCAS *et al*, 31.7.23

2.3.1 Classes of Bomber

At Trenchard's meetings it was generally agreed that continuous, day and night, bombing was essential to prevent recovery from the effect of attacks.[64] The Air Staff had noted that the radius of action of contemporary night bombers was greater than that of day bombers, yet saw the need to achieve equal effect by day and night.[65] The solution was seen to lie in the development of a dual-role bomber to equip the majority of squadrons, which, as Trenchard explained, could then operate by day or by night depending on time of year and degree of opposition.[66] He envisaged that there would also be a few squadrons of high-performance day bombers and of heavy night bombers.

Despite these intentions, no attempt was made to develop *ab initio* a dual role bomber until 1936. Rather, as shown in chapters 4 and 7, the Air Ministry specified operational requirements for short-range day bombers and longer-range night bombers.

2.3.2 No Fighter Escorts - but Various Bomber Escort Proposals

An issue on which the CAS's meetings appeared to agree a clear policy line and yet immediately cast doubt upon it was that of the escort of bomber formations. The Air Staff argued that fighter escort would be ineffective, and that, as has been quoted, the defensive fire of a bomber formation could be very effective. But it added that,

> In this connection it should be remembered that the defensive power of a bombing formation may be very much increased by the addition of bombing aircraft carrying extra ammunition and no bombs. These

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64 ibid., Minutes of 25th July 1923

65 ibid., 12B section 8

66 ibid., CAS to DCAS *et al*, 31.7.23

> aircraft will have a better performance and greater manoeuvrability than those which carry bombs.[67]

Yet surely a formation of bombers had no place for aircraft with a higher performance than the bomb-carrying aircraft, nor any use for its higher manoeuvrability. Paradoxically, when in 1935 a heavily-armed "escort bomber" was again proposed, in this instance to escort otherwise unarmed bombers, it was then rejected on the grounds that to be useful this aircraft would need a bottom turret and thus have a poorer performance than the rest of the formation.[68]

The question of escort for bombers was raised again in 1936. The Deputy Director Operations (Wing Commander G.C. Pirie) saw that in the Spanish Civil War bombers were being escorted by fighters. Although he thought that this might indicate poor leadership and indifferent formation flying, he observed that, "Nevertheless, these operations provide the only examples of modern air forces in actual conflict with each other since 1918." Pirie suggested that an operational requirement for a long-range fighter should be drawn up.[69] Air Commodore W.S. Douglas, Director of Staff Duties, remarked that in his view bombers should look after themselves, although he resurrected the thought that some might be more heavily armed at the expense of bomb load.[70] He drew attention to a paper on this concept by Flight Lieutenant Pharazyn.[71] This possibility was raised again in 1938 in connection with the Air Staff's search for an Ideal Bomber (discussed in chapter 9), and in February 1939. The Director of Operational Requirements then asserted, in the context of possible escort fighter types, that "I feel sure that the right answer is to provide bombers with the best possible

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67 8/71, ASM 11.A section 3

68 PRO: AIR 6/43, Expansion Progress Meetings. Memoranda June - December 1935, The employment of bombers without guns and fighters without bombs, Air Staff, 4th June 1935

69 PRO: AIR 2/2613, Fighter Escorts for Bombers, DDOps to DCAS, 23.11.36

70 ibid., DSD to DCAS, 30.11.36

71 ibid., 2A, Fighter Escorts

defensive armament and carry additional ammunition when necessary."[72]

All proposals to include special heavily-armed aircraft in a formation of bombers weakened the theory that the defensive effectiveness of a formation of bombers lay in its ability to bring a large number of guns to bear on attacking fighters. If only a small proportion of a formation could contribute to its defence throughout a long engagement, then much of this advantage would be lost. MacFarland and Newton underline this aspect in their comments on the conversion of some B-17F bombers to "flying antiaircraft batteries" in 1943. They note that whereas the additional firepower seemed impressive when compared to that of a single standard B-17, "when compared to a combat box of B-17s the increase in firepower was negligible." This experiment also confirmed that the fitting of an extra turret slowed down the "battlecruiser" and forced the bomber formation to throttle back. Macfarland and Newton say the operational "results were not promising."[73] Spick suggests that the production of this YB-40 battlecruiser, "would have gladdened the heart of General Douhet", but comments that they were "a dismal failure".[74]

What was lacking in the RAF for many years was a proper analysis of the defence of bombers. In 1924 Wing Commander T.R. Cave-Browne-Cave, commander of the Marine and Armament Experimental Establishment, noted that, "There appears to be no very firmly founded doctrine as to the proper defence for a bombing formation from attack by fighters."[75] Thirteen years later the RAF Staff College

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[72] PRO: AIR 20/167, Development of Fighter Planes, DOR to DDOps(H), 21.2.39

[73] MacFarland, S.L., and Newton, P.N., To Command the Sky, 1991, pages 101-102

[74] Spick, M., Fighter Pilot Tactics, 1983, page 94

[75] PRO: AIR 5/1132, Bombing and Bombing Tactics; Part 1, Item 1, Methods of Bombing and their Future Development, July 1924, page 12

was told that "it is only recently that bomber tactics have come to be taken seriously."[76]

It will be seen that belief in the ability of bomber formations to defend themselves was also to have a significant effect on RAF fighter development.

In the 1923 Provisional Home Defence Expansion Scheme provision was made for thirty-five "Bombing Squadrons" - the number which Trenchard had decided upon following his discussions with senior officers.[77] Pending further investigation these were to be divided into twelve day bombing squadrons and twelve night bombing squadrons, with eleven left undecided.[78]

Most bomber squadrons were to be stationed in Oxfordshire and Gloucestershire, where they would be protected by the Aircraft Fighting Zone (described below).[79] Bushby gives a map of the Zone and of bomber bases.[80] For many years the radius of action specified for most bomber types was no more than sufficient to reach Paris and the industrial regions of North East France from those bases.[81,82]

It has been noted in chapter 2 that the replacement of France by Germany as the potential enemy led to the need for much greater range for RAF bombers. It also meant that the best location for RAF bomber squadrons would be in East Anglia and Yorkshire.

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76 ibid., Item 22, Lecture by Wing Cdr. Saundby to the Staff College on Bomber Tactics Defence and Offensive Aspect, May 1937

77 5/416, CAS to DCAS *et al*, 31.7.23

78 8/73, Section 3. Strength and Composition of the Force

79 ibid., Section 4. Disposition of the Force

80 Bushby, J., Air Defence of Great Britain, 1973, page 82

81 20/84, Requirements for the New Day Bomber. Explanation of requirements and policy by C.A.S., Note of meeting on 2nd August 1923

82 Rowley, H.V., "The Striking Power of the RAF", JRUSI, Vol 80 (1935), page 144

2.3.3 Classes of Fighter

Trenchard's meeting on the 25th July 1923[83] discussed at some length the topic of day and night fighters. The main issue was the feasibility of using the same squadrons for both purposes. It was concluded that although separate squadrons and types might be ideal, within a total of only fifty-two squadrons it would be necessary to train pilots for both day and night fighting. It was this conclusion that led to the use of the same aircraft for day and night operations, for otherwise only part of the limited fighter force would be suitable for defence against an enemy concentration by day or by night.[84]

The Expansion Scheme specified a total of seventeen "Fighting Squadrons", and under the heading "Disposition of the Force", set out the principles which were to govern their deployment in some detail. These followed from the system set up in 1917-18 by Major General E.B. Ashmore, and recommended by the Steel-Bartholomew Committee.

In Air Defence, published in 1929, Ashmore explained that in 1917,

> The great principle of Air Defence was not yet sufficiently recognised: that although aeroplanes are the first means of defence, they are ineffective unless supported by a control system on the ground.[85]

Ashmore accepted that continuous patrols along the coastline were out of the question because of the expense in men, money and material. He concluded that defending fighters would have to be kept on the ground some distance inland. This distance would be determined by the rate-of-climb of the fighters, and the speed and height of the attacking bombers. On first warning of an attack crossing the coast the fighters would take-off and gain height.

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83 5/416, meeting on 25th July 1923

84 2/1069, Air Exercises of 1931, Air Ministry to AOC-in-C ADGB, 30th December 1931

85 Ashmore, E.B., Air Defence, 1929, page 39

Further sighting reports of incoming enemy aircraft would be telephoned to a central plotting table where their route could be assessed, and the defending fighters would be directed to intercept.[86] These ideas were to form the basis of the air defence system used in the Battle of Britain.[87]

Ashmore's principles were applied in the 1923 home defence scheme.[88] There was first to be an anti-aircraft Gun Zone, and then the Fighting Squadrons were to be,

> disposed in such positions as to enable them to meet enemy aircraft in a prepared zone drawn round and parallel to the coast at a distance of approximately 30 miles therefrom. This zone is termed the Aircraft Fighting Zone.

After the Aircraft Fighting Zone, there was to be a second, local (London), Gun Zone.

It was planned that fourteen of the seventeen "Fighting Squadrons" would be stationed in the Aircraft Fighting Zone, with each squadron assigned to a defensive sector which it would not leave. So was born the concept of the (Aircraft Fighting) Zone Fighter, which dominated Air Staff fighter requirements for many years. Zone fighters were to operate by day and night.

The remaining three fighter squadrons were to be stationed near the South coast. It was specified that, "The duty of these Squadrons will be to intercept enemy aircraft on their inward or outward journey. They will also afford protection to the south-east and to the coast towns in that area".[89] This plan appears to have followed from a proposal from Group Captain T.C.R Higgins when concern with the "Continental Air Menace" first arose in 1921. At that time six day-and-night fighter squadrons were planned

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86 ibid., page 37

87 Probert H. and Cox S. (editors), <u>The Battle Re-Fought</u>, 1991

88 8/73, section 4.(b) *Fighting Squadrons*

89 ibid., 4.(b)

to fulfil the zone defence role of repelling attacks on London. But in the context of the interception of enemy bombers on their return journey, Higgins suggested that,

> If and when a 7th Squadron is available for the Defence of London DETTLING (sic)[90] Aerodrome is an ideal locality, on which to base a Squadron devoted to the Role of Interception by Day.[91]

This idea of a squadron of day fighters - and later a specialised design for that role - was to have far-reaching effects on RAF fighter development in the 1930s.

In 1923 Trenchard wanted the squadrons based on the South coast to be known as "Advance" squadrons,[92] but it soon became the practice to refer to them as "Interception" squadrons, and so to the concept of an "Interception Fighter". It will be seen that the operational requirements of an interception fighter were importantly different from those of a zone fighter.

The problem of the defence of London and the distinction between zone and interception fighters is crucial to the understanding of RAF fighter development in the 1920s and 1930s. Failure to appreciate this has led many writers to misunderstand Air Staff policy on fighter design. It appears to be assumed that the terminology "interception" was merely a quaint form of the word interceptor. Typical are M. Bowyer's Aircraft of the Few[93] and Interceptor Fighters.[94] In describing the evolution of RAF fighters, Bowyer looks for a single line of development, jumping from zone fighter to interception fighter specifications and back. This can only lead to confusion, such as the deduction that the fast climb required of interception fighters was to replace standing patrols[95] - which were

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[90] Detling is near Maidstone, Kent

[91] 5/564, 5A, Defence of London against Aerial Attack, 12.11.21

[92] 5/416, meeting on 25th July 1923

[93] Bowyer, M.J.F., 1984

[94] Bowyer, M.J.F., 1991

[95] ibid., page 11

never RAF policy. More remarkably, Andrews and Morgan assert that it was only with the issue of the first specification for an interception fighter in 1927 that, "British defence strategists realised that the prior concern of a British fighter force in a future war would be to intercept enemy bomber attacks on Britain."[96] Mason finds it a paradox that the Hawker Fury (interception) Fighter served in only three squadrons,[97] apparently unaware that this was the full complement for such day fighters. Other examples will be noted in the discussion of fighter development in the mid-1930s in chapter 5.

The geography of the zone system of air defence was first conditioned by treating France as the potential enemy. The Aircraft Fighting Zone covered London from attacks from the South and fighter squadrons were stationed in Southern England. There was no need for a separate defence system for the Midlands and North because an attack from France would have to over-fly the defences of Southern England.

When Germany replaced France as the potential enemy, the Aircraft Fighting Zone was extended to cover attacks from the East, not only to cover London from that direction, but also to give protection to the Midlands and Northern England.[98,99] Otherwise the basic concept of the fighter defence organisation was unchanged. When, in the late 1930s, RDF (radar) was developed to give earlier warning of approaching aircraft, it was integrated into the established system of fighter control. Whereas radar made the reasoning which had led to an inland Aircraft Fighting Zone redundant, and the Outer Artillery Zone was abandoned,[100] the higher speed of contemporary bombers

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96 Andrews, C.F. and Morgan, E.B., Vickers Aircraft since 1908, 1988, page 238

97 Mason, The British Fighter, page 213

98 2/1386, Memorandum by Air Staff, 30th July 1934

99 Bushby, page 85 has a map of the Reorientation Scheme

100 41/14, page 38

still gave little time for interception between first warning and bombs falling on London.[101]

2.4 SUMMARY

The report of the Steel-Bartholomew committee, Trenchard's meetings and the Provisional Home Defence Scheme, led to a self-consistent set of decisions which fixed a strategy for home defence, the balance of offensive and defensive resources, and the broad types of aircraft which would be required.

The overall strategy was founded on the belief that the bombing of London could not be prevented - it was this which led to the adoption of a counter offensive as a deterrent. In this belief the Air Staff was to be proved correct, as it was also correct to suppose that it could not be prevented from bombing an enemy's cities. The weakness of the RAF's strategic doctrine was its optimism as to the accuracy, sustainability and effect of such bombing.[102] Its confidence in these has been demonstrated. In the event, it was found that accuracy was unattainable in the face of a resolute defence, and that much heavier bombing than had been thought sufficient was needed to weaken an enemy's production,[103] and even this did not bring about a collapse of his morale. Bombing became a war of attrition between the bombers and the defences.

Although it is common to deduce that the RAF's strategic doctrine was found to be unsound, it was the mistaken tactical doctrine of self-defending formations of day bombers, and the accuracy and effect which they could achieve, which undermined the strategy. The air forces of Germany and the United States went through the same

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101 PRO: AIR 2/2477, Problems of Air Defence, 16B, Memorandum by Air Staff for Air Defence Research Sub-Committee, 17th May 1935, section 4
102 Slessor, J., The Central Blue, 1956, page 205
103 Overy, R.J., The Air War 1939-1945, 1980, Chapters 2 and 5

learning process.[104,105] The converse of the failure of self-defending formations of bombers was that the RAF's day fighter defence force was much more effective than anticipated.

When it came to specifying the characteristics of the aircraft which would be the cutting edge of the doctrine expounded in 1923, for many years the Air Ministry failed to establish a clear procedure to determine what was needed. This omission is discussed in the next chapter.

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104 ibid., page 34
105 MacFarland and Newton, chapter 3

3. MANAGEMENT AND TECHNOLOGICAL BACKGROUND

The first part of this chapter describes and discusses the procedure whereby the Air Ministry conceived and developed the aircraft which it believed it needed for home defence. The conception stage of this process - which is the subject of the current research - was nominally the responsibility of the Air Staff, but there were important inputs from other parts of the Air Ministry, the operational Commands of the RAF, and at times from the aircraft industry. These interactions will be noted as they arise in later chapters. The purpose here is to describe the relevant organisational structure of the Air Ministry, the place of operational requirements and specifications in the complex procedure for aircraft procurement, and the way in which operational requirements were handled within the structure of the Ministry.

The second part of this chapter reviews developments in aerodynamics, structures and aero-engines during the 1920s and 1930s, and discusses their general impact on aircraft design and performance.

3.1 THE AIR MINISTRY

Grey's History of the Air Ministry[1] describes the major organisational changes which took place in the years covered by this thesis, but it does not deal with detail below the level of Deputy Director, nor do the Air Force Lists for the period. There are few surviving Air Ministry papers which do, but one of these, Air Marshal Sir Robert Brooke-Popham's 1933 "Report on Certain Points in Air Ministry Organisation",[2] has a useful review of that part of the organisation of most relevance to the

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[1] Grey, C.G., History of the Air Ministry, 1940

[2] PRO: AIR 2/673, War Organisation of the Air Ministry, 2A

current research. It enables the identification of relatively junior posts, which, as will become evident, had much influence on Air Ministry policy in regard to operational requirements.

The departments of the Air Ministry which concern the current research are those of the Chief of the Air Staff (CAS) and of the Air Member (of the Air Council) responsible for research and development.

From 1923 to early 1939 the Department of the Chief of the Air Staff included a Directorate of Operations and Intelligence, otherwise known as the Air Staff. It contained branches for Operations, Plans, and Intelligence, and from 1934 an Operational Requirements section. All were staffed by RAF officers, serving for between two and five years. The Director also held the post of Deputy Chief of the Air Staff and had a seat on the Air Council.

Early in 1938 the Department of the Chief of the Air Staff was re-structured. A new post of Assistant Chief was created, with, *inter alia*, responsibility for Operational Requirements, now a Deputy Directorate.[3] In the following year a Director of Operational Requirements was appointed. Operations, Intelligence and Plans were also upgraded to full Directorates.[4] Soon after the outbreak of war a second post of Assistant Chief of the Air Staff (ACAS(T)) was created whose sole responsibility was for Operational Requirements and Tactics.[5]

The Department of the CAS also contained other Directorates. At various times Organisation, Staff Duties, Works and Buildings, Signals, and Medical Services came directly under the Chief of the Air Staff.

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[3] PRO: AIR 2/2853, Re-Organisation of the Air Staff under DCAS and ACAS, approved 26th February 1938

[4] Air Force List, August 1939

[5] Postan, page 46

As regards responsibility for research and development, the appointment of an Air Member with that title (AMRD) was made in 1935. Before then research and development came under the Air Member for Supply and Research (AMSR). From June 1938 a post of Director General of Research and Development (DGRD) was created within a new department of the Air Member for Development and Production (AMDP). As the current research impinges slightly on the period after a Ministry of Aircraft Production had been set up in 1940, it should be mentioned that the research and development function went into the new Ministry, and somewhat later the post of DGRD was upgraded to Controller of Research and Development (CRD).[6]

Throughout the 1920s and 1930s the department of the Air Member who carried responsibility for research and development contained a joint Directorate of Technical Development and Research, with subsidiary branches dealing with Aircraft, Armament, Engines, etc.. This Directorate was staffed by RAF officers on short-term assignments and by permanent civilian professionals. Postan cites the role of Technical Development as,

> 'responsible for the design of aircraft as a whole, i.e. for its success in fulfilling given operational functions'. Its object was to bridge the gap between the operational requirements and the production orders in quantity.[7]

Of course the Directorate did not design aircraft itself, but it did fund, oversee, guide and judge the efforts of those who did. It also had a major influence on the initiation of new RAF aircraft. For example, it will be shown that this Directorate fostered the development of the Spitfire and Hurricane.

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[6] ibid., page 46

[7] ibid., page 49; the quote is said to be from an official survey

The Appendix gives the holders of those posts in the Air Ministry which are frequently referred to in this thesis. In following chapters RAF officers will be referred to by the rank they held at the time of the event under discussion.

3.2 OPERATIONAL REQUIREMENTS, SPECIFICATIONS AND AIRCRAFT PROCUREMENT PROCEDURE

Much has been written on the development of RAF aircraft types from specification to service, and on service experience, but there is little mention of the operational need the specifications were intended to meet. It is often suggested (after Beaverbrook[8]) that the best aircraft were conceived by industry, and that the Air Ministry then wrote a specification around them. Goulding and Moyes have noted the tendency to claim that the Air Staff were short-sighted, and that the only good aircraft came from private ventures. They point out, however, that,

> In truth, the vast majority of aircraft types entering service were the direct result of specifications issued after careful deliberation and technical discussion.[9]

This thesis will confirm that this was indeed the case for the home defence aircraft with which the RAF fought the Second World War.

3.2.1 Operational Requirements and Specifications

The first step in the Air Ministry's initiation of a new type of aircraft would be expected to be a discussion of the operational requirements - often referred to as Type Requirements, and later as Air Staff Requirements.

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[8] H. of L. Deb. Vol. 125, Col. 804, 27th January 1943 (cited in Postan, page 84)
[9] Goulding and Moyes, Bomber Command: 1936-40, page 44

Ideally these would define the aircraft performance and armament which the Air Staff saw as needed to carry out its strategic policy. But the setting of operational requirements seldom emerged from such an *a priori* analysis, and was sometimes initiated from outside the Air Staff. Most new types began simply as replacements of aircraft which were in service. The driving force was the need to take advantage of developments in aviation technology to obtain a higher performance. Nevertheless, it will be seen that, however consideration of a new type was begun, it could lead to debates which illuminate the RAF's perception of the future of air warfare, and of the aircraft characteristics which were thought to be desirable.

When, one way or another, agreement was reached on the operational requirements for a particular purpose, these would be the basis for a specification. A specification was a formal contract document - an invitation to tender - and as such was expressed in engineering and contractual terms. It included the operational requirements, although not explicitly before 1934.

Before proceeding further in the description of Air Ministry aircraft procurement procedure it will be helpful to describe the numbering system used for specifications, because specification numbers were used widely in the Air Ministry - and are hereafter - to refer to aircraft projects.

A typical specification number would be in the form F.20/27. The first character denoted the class of aircraft. From the late 1920s this was "F" for fighters and "B" for bombers. The number before the slash denoted the order in which a number had been assigned to projects for which contracts were expected to be issued in the (financial) year denoted by the number after the slash. Thus F.20/27 was a fighter project which was the 20th of all those new aircraft which had been considered for ordering in 1927-28. B.9/32 was a bomber project which was ninth in the 1932-33 programme.

For a number of years in the 1930s it was intended to use "L" for light bombers, "P" for medium bombers and "B" for heavy bombers, so that in the 1936 programme B.12/36 was a heavy bomber and P.13/36 a medium bomber. This subdivision of bombers was inconsistently applied and it was discarded early in 1937.[10]

The specification number was often assigned at early stage in the consideration of a new aircraft, and would then be attached to its operational requirements - before the specification itself had been drawn up. It will be seen that sometimes issue of a specification did not follow an operational requirement. On other occasions, if a project had slipped into a later financial year, the designation of a specification might be changed from that first assigned to the operational requirement. For example B.1/39 was the delayed B.19/38.

The Air Ministry was usually seeking performance at the upper limit of the technically possible, so that operational requirements would be expressed in order of priority and in relative terms - the highest possible speed, highest possible rate-of-climb, high manoeuvrability, etc.. Such characteristics were often competing aims in design optimisation, so in addition maxima or minima were given where appropriate. These limits were derived from project studies carried out by the Research and Development (Aircraft) branch of the Air Ministry, under the leadership of Captain R.N. Liptrot, a qualified aeronautical engineer.[11] They provided a set of

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[10] PRO: AIR 20/78, Nomenclature and Revised System of Designation of Types of Aircraft, DCAS to CAS, 12.1.37

[11] For example, in PRO: AIR 2/729, 9A, 10.5.34, Liptrot describes performance calculations for a series of hypothetical aircraft which had been laid out to meet an Air Staff requirement.

realistically attainable performance aims based upon the current state of technological development. When coupled with the required normal fuel and military (mainly crew, armament and bombs) loads, they set the performance to be met in acceptance trials of prototypes designed to the specification.

In October 1933, as part of an attempt to shorten development times, it was proposed that Air Staff Requirements (i.e., operational requirements) should be circulated to firms immediately after they had been agreed. (As Appendix "B" of the forthcoming specification). At the same time firms would be told of the expected date of issue of the specification, and who would be asked to tender.[12] This procedure was adopted towards the end of 1934.[13] It was an improvement on previous practice for, as the Director of Technical Development noted, operational requirements had previously been scattered throughout a specification, with no clear picture of the overall intention.[14] The performance data now given in Air Staff Requirements replaced these dispersed references.

In the 1920s and early 1930s it was not unusual for operational requirements and specifications to be developed together. A specification drawn up by the technical branches of the Air Ministry would be modified by the Air Staff to meet their wishes. Later, when a formal procedure for developing operational requirements had been established, there continued to be an interplay between the Air Staff's wishes and their technical feasibility.

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[12] 6/22, Air Council Precis, ACM 572 Acceleration of Design and Development, 11th October 1933, para.7(a)

[13] from specification files held by the Air Historical Branch, Ministry of Defence, P.4/34 appears to be first for which this procedure was followed.

[14] PRO: AIR 2/1668, Experimental Aircraft New Procedure for Ordering, DTD to AMSR, 15.1.35, para.2

An important output of the current research is to trace in detail the route whereby important operational requirements were developed, so as to understand the Air Staff's intentions, and to establish the correct timetable of events. This will be seen to give a new perspective on the origins of many of the aircraft with which the RAF fought the Second World War.

3.2.2 Post-Specification Procedure

Although this thesis is not greatly concerned with aircraft development beyond the consolidation of operational requirements, it will be helpful to outline the steps in aircraft development which followed the issue of a specification.

The Air Ministry's practice was to invite a number of aircraft manufacturing firms to tender design proposals to a specification for a new type of aircraft. Following analysis and comparison of these designs by the technical Branches of the Air Ministry, assisted by the Royal Aircraft Establishment, a number of firms (usually two or three) would be contracted to build prototypes. These were then subjected to extensive testing, together with any which had been built to the specification as a private venture. One or more of those tested might be chosen for limited production - perhaps to a modified specification - for development trials in squadron service. Finally a decision would be made as to which model(s) should be ordered for full production.[15] As in other businesses, a new specification would usually be issued for the production model.

Thus an operational requirement could lead to a number of specifications. For example, specification B.9/32 for a

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[15] PRO: AIR 20/68, Aircraft Development Programme; Notes on Conferences (from 1925), page 134, A Table of the Stages of Design and Development of Aircraft, c.1926

twin-engined day bomber was issued in 1932. It was followed by three production specifications, all issued in January 1937. These were 29/36 (Wellington), 30/36 (Hampden) and 44/36 (Hereford). As compared with B.9/32 these included an increase in bomb load, and, for the Wellington, in armament.[16] (Note that the letter denoting the class of the aircraft was often dropped from production specifications.) The situation could also arise that a new project was not given a designation until a contract was awarded - the Hawker Demon and Hurricane are such examples. In the latter case there was a specification number but no corresponding specification document.

Clearly, unless one identifies the first thoughts on a new project, there is scope for misinterpretation and the assignment of credit where it does not belong. This is well illustrated in chapter 5 where a variety of versions of the origin of the Spitfire and Hurricane is discussed.

In the mid-1930s attempts were made to shorten the time taken to develop a new aircraft. After discussions within the Ministry and with industry,[17] the procedure outlined above was retained, but with a fixed timetable for each stage of design and development,[18] and omission of the twelve-month squadron development period.[19] It was hoped that these changes in procedure would cut the development time by half.[20] They were adopted by the Air Council in May 1935,[21] but Dowding was to comment three months later that, "All this is now held up by the production of Lord Weirs [sic] alternative scheme."[22]

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[16] These examples are taken from specification files held by the Air Historical Branch, Ministry of Defence.

[17] 2/1668, 8A, Minutes of a Meeting held ... on 10th December, 1934, to discuss a new system of ordering Experimental Aircraft

[18] ibid., 11A, New types of Service Aircraft - Acceleration of Design and Development, para.5

[19] ibid., 11A, para.8

[20] ibid., 11A, para.6

[21] ibid., 14A extract from Air Council Minutes of 155th Meeting , 7th May 1935

[22] ibid., note by AMRD, 19.8.35

Lord Weir, in his capacity as adviser to the Air Council, had proposed a more radical change in procurement procedure, which he wrote was "almost the most important matter of policy on which I have been consulted". Weir claimed that the state-of-the-art of aircraft design was such that, "the actual performance and qualities of design can be accurately predicted from the design."[23] His contention was firmly contradicted by both the aircraft industry[24] and the Air Ministry - the Secretary quoted a recent opinion of the United States Federal Aviation Commission that, "We cannot accept it as desirable that the prize for a design competition should be awarded to that Competitor who is able to support the tallest claims."[25]

In fact dispensing with the prototype stage of aircraft development had already been considered by the Air Ministry as part of its review of the timetable of aircraft development. It was then noted that such a scheme was "said to have been adopted by the Italians", but the Ministry's unanimous view was that it would lose the advantages of competition, and lead to a loss of time and money if a chosen design was unsuccessful.[26] An example of the dangers of by-passing prototype testing is given by Vann's history of the Me 210 project.[27] (The author recalls a remark by Sir Sidney Camm in 1960 that the only way to know whether a new design was successful was to get a prototype in the air as soon as possible.)

In his biography of Lord Weir, Reader notes that Weir's proposals were never adopted as Air Ministry practice.[28]

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[23] 6/43, Expansion Progress Meetings, EPM 21(35), Acceleration of Design and Development of Service Aircraft. (Note by Lord Weir), 21st July 1935, page 1,

[24] ibid., EPM 45(35), T.O.M. Sopwith to The Rt. Hon. Sir Phillip Cuncliffe-Lister, 29th October 1935

[25] ibid., EPM 53(35), para. 2

[26] 2/1668, 11A, para.4

[27] Vann, F., Willy Messerschmitt, 1993, Chapter 10 "The Me 210 disaster"

[28] Reader, W.J., Architect of Air Power; Life of Viscount Weir, 1968, page 218

Nevertheless, to shorten the time from inception to production the Ministry did order some new types 'straight from the drawing board'. This procedure, and other attempts to shorten the timescale of development are described by Postan. He comments that despite these efforts, "the problem remained largely unresolved."[29]

3.3 RESPONSIBILITY FOR INITIATING NEW AIRCRAFT

This thesis is closely concerned with the ideas that led to the development of new RAF aircraft, and the management process through which these evolved is of some importance. There were two distinct phases - from the early 1920s to 1934, and from that year to the outbreak of war.

3.3.1 1923-1934

The Air Historical Branch of the Air Ministry has described operational requirements as having been dealt with in a piecemeal fashion before 1934.[30] This will be shown to be fair comment, for although a clear procedure was defined, it was not always followed in practice. Some examples will be given to illustrate the misunderstandings which could result.

The procedure that was meant to be followed for initiating new aircraft types was set out in an "Office Memo" dated June 1923. For military aircraft a "Type Requirements" file was to be opened by the DCAS and was to state the type contemplated. After the new type had been accepted into the experimental aircraft programme, the file was to be passed to the technical branches of the AMSR's department for a specification to be prepared. The specification was then to be referred back to the DCAS for

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[29] Postan, pages 142-147
[30] 41/39, page 54

his final approval.[31] This Office Memo is one of the few records which indicate the Air Ministry's intention that new types should originate with the Air Staff, and the intended distinction between type (or operational) requirements and specifications. It did not specify where responsibility for operational requirements lay within the Air Staff, but a clue is to be found in Richards' biography of Portal.[32]

Richards notes that Portal was appointed to the Flying Operations (Home) section of the Air Staff in April 1923. He cites a 1964 paper in which Portal wrote that his "job was 'Home Operations', but there were only a few squadrons in the country and I turned myself into a kind of rudimentary Operational Requirements branch".[33] This casual approach to the assumption of responsibility for operational requirements was confirmed by Brooke-Popham in 1933. He noted that the FO1 (Flying Operations 1) section had originally been formed to consider home defence, but that shortly afterwards it began to deal with operational requirements in aircraft and armament. This had become the bulk of the work of two of the three officers in the section. Only the third now dealt with the strategy of home defence. Brooke-Popham proposed that there should be a new section of the Air Staff specifically for Operational Requirements, and that this should come directly under the DCAS. It was to deal with all types of aircraft, equipment and armament, other than that for the Fleet Air Arm, and "would form the channel of communication on such matters between the Air Staff, both Operations and Training, and the Technical Research Departments."[34] The new section was created in April 1934.[35]

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[31] PRO: AIR 20/82, Aircraft Type Requirements Procedure, Office Memo dated 8th June 1923

[32] Richards, D., Portal of Hungerford, 1977, page 82

[33] Portal, C., The Air Force Department Society Journal, May 1964

[34] 2/673, 2A, pages 14 & 15

[35] ibid., 44A, Organisation of the Department of the Chief of the Air Staff and the Department of the Air Member for Personnel

As has been noted earlier, proposals for new aircraft also emanated from the Research and Development Department. Some of these were research projects brought forward to explore their potential for military (or civil) use, but others were replacements for existing Service types.

Whatever the source of a proposal for a new aircraft, they were all regarded as experimental, and were brought together in annual Experimental Aircraft Programmes. These programmes were drawn up by the AMSR's department and discussed with the Air Staff, but the AMSR could, and did, proceed with projects which were not approved by them. It is not surprising that the Air Staff complained that the AMSR had aircraft built for which the Air Staff had no use. Conversely, the technical branches were annoyed that the Air Staff criticised their proposals instead of producing operational requirements. This lack of direction in the formulation of operational requirements, and the ambiguity of the role of the AMSR's Department, are well illustrated below by examples taken from 1927.

The development of an interception fighter is described in detail in chapter 4.4.2. It began early in March 1927 when the Chief of the Air Staff (Trenchard) saw the draft of a zone fighter specification, No. 27/26. He told the AMSR, Air Vice Marshal Sir John Higgins, that there were already four such types being built, and stressed that he wanted an "Interceptor". Trenchard suggested that a specification for one should replace specification 27/26.[36] Faced with this proposition, Higgins asked his Director of Technical Development (Air Commodore J.L. Forbes), "Have we at any time been given the general requirements of the Air Staff for the 'Interception' type?".[37] They had not,[38] and Higgins minuted Forbes,

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36 PRO: AIR 2/767, Single-Seat Fighter Landplane Spec 27/26, CAS to AMSR, 4.3.27

37 ibid, AMSR to DTD, 7.3.1927

38 PRO: AIR 2/794, Interception Fighters for Home Defence: Type Requirements, DTD to DCAS, May 1927

> I don't know how the practice originated of sending detailed specifications to the Air Staff for their approval. It appears to me to be wrong. It is for Air Staff to tell us general lines on which they want a machine produced and what they want to put in it and for us to translate it into technical details.[39]

Whilst financial restrictions had not permitted the development of two classes of single-seat fighter, it was surely the Air Staff's duty to have considered the operational requirements of the interception class, if only to establish whether the requirements were importantly different from those of a zone fighter.

A different perspective on the complaint of Higgins quoted above is given by the development of a multi-gun fighter, which is discussed in chapter 4.4.1. In this case the technical department initiated the project and ignored the Air Staff's comments.

At a meeting in October 1926 to consider the Experimental Aircraft Programme for 1927, the AMSR's department put forward a proposal for a single-seat six-gun fighter. The Air Staff believed that such an aircraft would be useless because of its low performance, but it was claimed that the performance would be better than that of day bombers, and that the aim was to assess by full-scale tests the actual loss of performance caused by fitting six guns. The AMSR (Higgins) supported the project - he said that he was influenced by similar developments in other countries. The item was finally agreed.[40]

The following March - the month of Higgins' complaint quoted above - the DTD (Forbes) wrote to the DCAS to confirm that the 1927-28 Estimates provided for the development of an experimental multi-gun single-seat

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39 2/767, AMSR to DTD, 11.3.27

40 20/68, pages 128-132, Conference to decide New Programme for Experimental Aircraft for 1927, 7th October 1926, Item 6

fighter.[41] He mentioned that as the gun load was higher than usual they proposed to have no radio and a relatively low fuel load. The DCAS replied that to be "of some value" the aircraft must have either the performance of an interception fighter with the proposed reduced military load, or match existing zone fighters with full military load; in both cases the Air Staff would accept a reduced fuel load.[42] It will be shown in chapter 5 that acceptance of a reduced fuel load to achieve a multi-gun fighter was a vital contribution to the development of the Hurricane and Spitfire in 1935, but in 1927 there was no prospect of the proposed six-gun fighter meeting either of the DCAS's alternatives. Nevertheless, the AMSR's department issued a specification and ordered a prototype from Gloster.

This episode clearly rankled with the Air Staff. Five years later, the then FO1 (Wing Commander A.C. Maund) saw that the Air Estimates included £30,000 for High Speed Research Aircraft. He advised the DCAS that although this item was not requested by the Air Staff, there was "no objection to A.M.S.R. developing this type if he has the money, there is no need to press for its being replaced on high priority." Maund added,

> I suggest, however, that in order that the misfortune which occurred with the Gloster multi-gun machine should not be repeated, you ask A.M.S.R. if he has any other Service use in view for these machines and, if so, that we should be given a chance to comment on the specification for the reason stated above.[43]

In chapters 5 and 6 it will be seen that the Gloster Multi-Gun Fighter actually did serve a valuable purpose. Moreover, the then AMSR (Air Marshal Sir Hugh Dowding) did not consult the Air Staff before he ordered two

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41 PRO: AIR 2/778, Multi-Gun Fighter Specification 10/27; Type Requirements, DTD to DCAS, 3.3.27

42 ibid., DCAS to DTD, 24.3.27

43 20/68,, page 76, FO1 to DCAS, 29.9.32

experimental high-speed aircraft in 1934. They became the Hurricane and Spitfire.

The handling of the issues described above illustrates the uncoordinated way by which the Air Ministry dealt with the analysis of its operational requirements. Yet this was an essential step in getting the means to implement its strategy. In later chapters it is shown how the failure to translate the strategy of the Home Defence Scheme into a coherent set of operational requirements led to the equipment of bomber squadrons with aircraft which could not fully implement the fundamental strategy of continuous day and night bombing. It also led to day-and-night fighters which were inadequate in either role.

These problems arose from two sources. First was the failure of the Air Staff to analyse the operational characteristics of the aircraft required to implement the home defence strategy. Second was the replacement of this omission by the initiation of technically interesting projects by the technical branches of the Air Ministry. There were occasional inputs from the operational Commands, but these were seldom taken seriously. Overall, whilst the RAF's fighters and light bombers were kept at the forefront of aviation development, its equipment was not closely related to the implementation of its strategic policy.

3.3.2 A New Procedure

In 1933 the unsatisfactory nature of the process by which the Air Ministry was initiating new aircraft was recognised and moves were made to rationalise the system. These included the actions noted earlier - the establishment of an Operational Requirements section in the Directorate of Operations and Intelligence, and arrangements to give designers early sight of Air Staff

Requirements. In addition steps were taken to co-ordinate strategic, technical and operational inputs through the establishment of what became known as the Operational Requirements Committee, and to eliminate divided responsibility. These are discussed below.

Air Vice Marshal E.R. Ludlow-Hewitt was appointed DCAS on 1st February 1933. It will be evident from later chapters that he made a number of important contributions to rationalising Air Ministry policy in regard to types of aircraft. One of his first actions was to tackle the problem of formulating operational requirements. In April 1933 Ludlow-Hewitt wrote to the CAS (Air Chief Marshal Sir Geoffrey Salmond) on this topic. He said that FO1 had formulated Air Staff operational requirements for replacement or new aircraft, and that these had then been submitted to the CAS for approval prior to the AMSR proceeding to meet the requirements. Ludlow-Hewitt's objection to this procedure was that although FO1 might have consulted individual officers in the departments of the Air Ministry, he had not obtained official departmental views. The DCAS thought that "it was quite unsound that F.O.1. should be the sole adviser to the C.A.S. on this important question". It will be clear from the examples given above that Ludlow-Hewitt described the process of formulating operational requirements as it was meant to have been over the previous ten years, but not as it always had been.

The DCAS proposed a new procedure which would formally involve both the departments of the Air Ministry and the operational Commands of the RAF. The key features were:-

(a) The A.Os.C. of overseas Commands should be asked to submit annually their views as to the operational requirements for replacement or new types for their Commands.

(b) A Committee should be set up to advise the C.A.S. as to the operational requirements that should be called for in the proposed new or replacement types of aircraft.

(c) The Committee should consist of:-

D.C.A.S. Chairman.

Representative(s) of A.M.S.R.

D.O.S.D. [Director of Organisation and Staff Duties]

D.D.O.I.

Representative of Plans.

A representative of the A.O.C. of an appropriate Command at home, if applicable.

The Committee should sit as and when required and the Chairman should co-opt additional members if he considers such action desirable.

Ludlow-Hewitt proposed that the committee's recommendations should go to CAS, and that if he approved them, the AMSR's Department would draw up a specification in consultation with FO1 (or FO2 for flying boats). If the DCAS accepted that the specification covered the Air Staff requirement, it would be issued to industry.[44] This scheme was adopted, although not wholly with immediate effect.

Meetings of the kind proposed by Ludlow-Hewitt were first held in 1934, although the title "Operational Requirements Committee" did not come into full use until 1935. The committee continued to be chaired by the DCAS after the Operational Requirements branch was put under the new post of Assistant Chief of the Air Staff in 1938.[45]

Following the first 'Operational Requirements Committee' meetings in March 1934, at which new light and heavy bombers were considered, Ludlow-Hewitt explained to the CAS that,

[44] 20/82, DCAS to CAS, April 1933

[45] 2/2853, Re-Organisation of the Air Staff under DCAS and ACAS, approved 26.2.38

> In making out these specifications I have endeavoured to give, for the information of the designer, a general statement in the first paragraph of the primary characteristics of the required type. The object of this paragraph is to give the designer definite guidance as to these primary characteristics, to which other items in the specification must if necessary be subordinated. A.M.S.R. will then be in a better position to ask for the assistance and suggestions of the firms in working out the means by which the primary requirements can best be met.[46]

This procedure was followed thereafter.

Divided responsibility for the initiation of new service aircraft was dealt with in October 1934. The Minutes of a meeting on the next year's Experimental Aircraft Programme record that,

> A.M.S.R. stated that before considering the items on the proposed programme he wished to comment on the method of approach to the problem which had hitherto been followed. It had been the practice for D.T.D. to prepare a draft programme for discussion, but he considered that it should be initiated by the Air Staff. D.C.A.S. agreed that in future the Air Staff should be responsible for initiating the programme of proposed new types of service aircraft, D.T.D. adding to this any projected items for Research or Experimental purposes.[47]

It is indicative of the importance attached to control of the Experimental Aircraft Programme that the decision to make it the responsibility of the Air Staff immediately led them to take positive steps in regard to the assessment of the aircraft types needed by the RAF - more so than had either Ludlow-Hewitt's new procedure, or the creation of an Operational Requirements section. The day after the AMSR's statement the DCAS (Ludlow-Hewitt) instructed Plans branch that, "In connection with the formulation of specifications for Service aircraft

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[46] PRO: 2/729, Heavy Bomber Specification B3/34. Type Requirements, DCAS to CAS, 13.3.34

[47] PRO: AIR 2/716, Experimental Aircraft Programme for 1935: Air Staff requirements and order of priority, 6B, Minutes of 16th October 1934

required in the future, I want you to prepare a review of the nature of operations required of the various air units stationed East of the U.K., both actual and proposed".[48] This request was similar to the first stage of Ludlow-Hewitt's new procedure, although, as became evident, the "nature of operations" was not the same thing as operational requirements.

Plans branch produced a Table which set out the duties and roles of each overseas Command, and the number of squadrons of different types which was needed, but with only peripheral reference to the operational characteristics required of each type.[49] It concluded that only a torpedo bomber and a General Purpose aircraft were different from those required for home defence.

It is interesting that the General Purpose type was not specified for Air Control duties, as some believe (chapter 4), but was defined as being able to engage a cruiser, with a bomb load of 500 lbs, and with adequate offensive and defensive armament.[50]

The Deputy Director of Operations and Intelligence (Wing Commander R.H. Peck) then sought to widen the review of the aircraft types required to include the whole of the RAF. He pointed out to the DCAS that,

> As you know, we have not had a careful appreciation of this kind before although it is really an essential first stage towards a stabilised equipment policy to provide a regular inflow of new designs. Moreover, without it it is exceedingly difficult to decide what operational requirements to lay down for each class of aircraft so that the number of classes can be reduced as low as possible without sacrificing essential characteristics in any one class.[51]

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48 PRO: AIR 2/2715, Classes of Aircraft Required by the Royal Air Force, DCAS to Plans, 17.10.34

49 ibid., 2A

50 ibid., Cochrane [Plans] to DCAS, 9.11.34

51 ibid., DDOI to DCAS, 15.11.34

In fact Wing Commander W.L. Welsh (FO1) had prepared a general review of home and overseas type requirements for a lecture to the RAF Staff College in 1928, but this does not appear to have been seen as an executive document. It is fully discussed in chapter 4.

Peck's proposal to extend the 1934 review was not accepted by Ludlow-Hewitt. In regard to the home defence classes - which he listed as heavy, medium and light bombers, two-seater, single seater (general) and single-seater (special) fighters - he said that, "These classes constitute the backbone of the Air Force and cannot be amalgamated or combined to get the very best results out of each class."[52]

Undeterred, Peck sought - without success - to persuade the Operational Requirements section to undertake a review of all future requirements, and their possible amalgamation. He suggested that they should include a comparison with foreign aircraft, particularly to see if parity in numbers would give parity in bombing capacity.[53]

Ludlow-Hewitt's replacement as DCAS in January 1935 by AVM C.L. Courtney brought a change of heart, for Courtney instructed Peck to produce a note on all the classes of aircraft required by the RAF, and on the rate of replacement. Peck's review of May 1935 concluded that there was little prospect of reducing the number of classes below those already seen as required for home defence and overseas. Indeed, he pointed out there were some omissions, such as high altitude bombers and fighters.[54,55]

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[52] ibid., DCAS to DDOI, 27.11.34
[53] ibid., DDOI to OR, 11.12.34
[54] ibid., 6A, DDOI to DCAS, 13.5.35
[55] ibid., 6B, The Classes of Aircraft required for the Royal Air Force and the policy on which obsolescent aircraft should be replaced

Otherwise, Peck's review was notable for some conclusions which were to be rapidly overtaken, as will be shown in chapters 7 and 8. He thought that there was no merit in increasing the bomb load of heavy bombers, and that despite its low "output efficiency" the light bomber class should be kept. Peck did, however, correctly foresee the merging of the zone and interception classes of fighter.

Another input to the management of operational requirements followed from the establishment in 1934 of Bombing and Air Fighting Committees. They included in their terms of reference the consideration of aircraft design in relation to bombing and fighting performance.[56] The Air Fighting Committee was to have some influence on armament issues (chapters 6 and 8), and Bombing Committee played an important part in discussions of an Ideal Bomber in 1938 (chapter 9).

3.3.3 <u>Summary</u>

During Ludlow-Hewitt's spell as DCAS the Air Ministry's management procedure for considering operational requirements was greatly improved. It will be seen that the Operational Requirements Committee provided a valuable forum for the bringing together of views of the Air Staff, the Research and Development department and the operational Commands of the RAF. Meetings were held to discuss the requirements for most of the post-1933 aircraft which are discussed later in this thesis.

During the Second World War, the Directorate of Operational Requirements was largely devoted to keeping the aircraft conceived before the war battleworthy.[57] But as the end of the war approached the Director proposed an extension of Ludlow-Hewitt's scheme by setting up a sub-

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56 PRO: AIR 5/1143, <u>Bombing Air Fighting Committees. Interim Reports</u>, paras. 2 and 48

57 PRO: AIR 20/2240, <u>Operational Requirements</u>, DOR to ACAS(TR), 19.3.1945

committee to look at future requirements as a whole. It was decided that this should include representatives of aircraft designers as well as of the Air Ministry and the Commands.[58]

3.4 TECHNOLOGICAL BACKGROUND

It is inevitable that the subject of this thesis raises technical issues concerning aircraft design and operation. This section summarises developments in aviation technology during the 1920s and 1930s, and discusses their general impact on aircraft design and performance. Some particular aspects which were important to the RAF's assessment of feasible operational requirements are noted. The section concludes with some cautionary words on aircraft performance comparisons.

3.4.1 Aerodynamics

Aerodynamics is the branch of science concerned with the flow of air. An understanding of the physics of air flow when treated as a non-viscous incompressible fluid had been developed before the first flight of a heavier-than-air machine, and the principles of its mathematical treatment were well established by the end of the Great War. This academic work was of little direct value in the design of practical aircraft. It was known that viscous effects were important in determining aerodynamic forces, but their inclusion in calculations of the aerodynamic loads on complex shapes had to await the advent of sufficiently large computers in the 1980s.

The progress that was made between the wars in the understanding of air flow and in the interpretation of wind tunnel tests was certainly beneficial. It led to an

[58] ibid., ACAS(TR) to DOR, 15.5.45

appreciation of the need for clean (streamlined) design and to comparative data on the performance of wing sections and of engine installations - all essential if advantage was to be taken of increased engine power. In the early 1930s devices such as slots and flaps came into general use to increase the lift which could be obtained from a wing at low speeds.

3.4.2 Aircraft Structures

During the 1914-18 war the load-bearing structure of most aircraft had been made of wood. This practice continued after the war, but there were difficulties in obtaining suitable wood and problems of storage, particularly in the tropics. Moreover metal structures were more suitable for mass production.[59] The Air Ministry took the lead in persuading the British aircraft industry to design metal aircraft. In 1925 it decided to equip the RAF with only all-metal aircraft[60] (something of a misnomer because wooden secondary structures and fabric covering of metal load-bearing structures continued in use for many years). The adoption of this policy, coupled with the statement that the RAF would buy no wooden aircraft after 1st April 1928, and would run down its employment of woodworking trades, was a bold move. Its success was exemplified by comments from the Director of Contracts of the Air Ministry in February 1929. He wrote that,

> In the last three years a silent revolution in construction has been proceeding with remarkable speed and smoothness. Considering the difficulties, technical and financial, which confronted the Ministry in 1925, and the gloomy forebodings then expressed, it is a matter of surprise that so momentous a change has been carried through with so little friction.

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[59] 6/22, Air Council Precis No. 539, Charlton Report, 2nd December 1926

[60] PRO: AIR 2/1208, Equipment of RAF with All Metal Machines - Policy, Extract from Air Council Minutes , 3rd December 1926

He noted that, "I understand from A.M.S.R. that in another 12 months there will be hardly any wooden machines in service, except for training."[61] Nevertheless, as noted in chapter 1, the myth that in the early 1930s the RAF was equipped with all-wooden aircraft has persisted.

The next step in the development of aircraft structures was a move to stressed-skin construction. Fabric covering was replaced by a metal skin which contributed to the load-carrying strength of the aircraft's structure. By the mid-1930s this had become general practice for new first-line military aircraft, with Vickers' "geodetic" construction an exception.

3.4.3 Aero-Engines

Improvements in aircraft performance came in the first place from increases in the power, power/weight ratio and fuel economy of aircraft engines. It was these which made higher speeds and longer ranges possible, and thus made improvements in aerodynamic design both desirable and exploitable.

The Air Ministry did not issue operational requirements for aircraft engines.[62] It did, as will be seen, support engine manufacturers to ensure that a British engine development and manufacturing capability was maintained.

Gunston's Piston Aero Engines[63] gives an excellent review of aero engine development between the wars, explaining both the problems of obtaining increases in power and how these were tackled, including the widespread introduction of supercharging to maintain engine power to high altitudes. These developments led to the power available

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[61] ibid., 24A, Note by Director of Contracts, 21.2.29
[62] PRO: AIR 20/92, Operational Requirements for Aero-Engines, Extract from 2nd Meeting of DGRD/ACAS Monthly Liaison Meetings, 16th February 1939, Conclusion 10
[63] Gunston, Bill, Piston Aero Engines, 1993, Chapter 6

to aircraft designers increasing from about 200 hp in 1920 to well over 1,000 hp in 1940. This increase in power was accompanied by marked improvements in engine and cooling system installation for low drag.

In the 1930s metal propellers began to replace the wooden propellers which had been in use, and the introduction of variable-pitch propellers made possible the optimum use of high power engines at both low and high aircraft speeds.

3.4.4 Aircraft Design

This section briefly discusses the influence on aircraft design of the technical developments described above. It must be remembered that aircraft design is a compromise between conflicting operational requirements, such as a high maximum speed and low landing speed, and between conflicting technical requirements, such as a strong wing but of low structure weight, or a well-cooled yet streamlined engine installation.

By the end of the 1914-18 war aircraft had been developed into acceptably reliable vehicles, certainly for military purposes. In the course of this development aircraft designers had explored a number of basic configurations. It had been found that the biplane configuration gave a good compromise between structure weight and aerodynamic performance at the speeds then possible with the engine power, and materials, that were available. For military purposes the biplane configuration could give the good manoeuvrability and high rate-of-climb that were sought for fighters. For bombers, load-carrying could be achieved by a large wing area, so retaining a low wing-loading. The latter was an important consideration at a time when take-off and landing on relatively unprepared surfaces was the norm, and when night landing aids were rudimentary. Design digressions into monoplanes and triplanes had been tried, not without some success, but by the end of the war biplanes dominated contemporary designs.

In the ten years following the Great War there was little change in the choice of configuration of aircraft designed for military applications. All the home defence aircraft which entered RAF service in those years were biplanes. Such modest improvements in the performance of RAF aircraft as did arise came largely from increased engine power and improved engine installation.

In the late 1920s and early 1930s improvements in materials and design began to be exploited in racing aircraft. The Schneider Trophy races are the best known of these, and illustrate the application of emerging possibilities for improving the high-speed performance of aircraft. The Trophy was donated in 1913 to encourage the development of hydro-planes. In the later years of the competition this brought the advantage of no limitation on airfield size. Thus the ever-present design compromise between the need to take-off and land safely in a restricted area, and the achievement of high flight speeds, could be loaded in favour of the latter.

In the years immediately following the Great War increases in winning speeds were obtained from improvements in the streamlining of biplanes, for there was little change in available engine power between 1920 and 1925.[64] By 1925, the American Curtiss R3C-2 realised all the potential for clean design of a biplane configuration. The Italian winner of 1926, as well as Reginald Mitchell's abortive Supermarine S.4 of the previous year, and his S.5 (the 1927 winner), took the next step in drag reduction with monoplane configurations, albeit wire-braced except for the S.4.[65]

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[64] Buchanan, J.S., "The Schneider Cup Race, 1925," JRAeS, Vol 30 (1926), page 434
[65] Barker, R., The Schneider Trophy Races, 1971

This demonstration of the value of aerodynamically clean design was not overlooked by the designers of military and civil aircraft, but it was not directly applicable to non-racing aircraft. The Supermarine Schneider Trophy winners of 1927-1931 obtained their high power from engines of very short life; they also carried very little equipment, had almost no view for the pilot, and very high landing speeds. When in 1931 the aircraft designer Richard Fairey analysed the changes that would be needed to produce a practical fighter, he concluded that it would be little better than those in service with the RAF if the comparison was made at the same engine power.[66]

In parallel with the development of racing seaplanes in Italy and Great Britain in the late 1920s, American military and civil aircraft designers began to put together the technical opportunities that were emerging. They recognised that increases in engine power provided the potential for higher speeds, but that the strut- and wire-bracing of wings, which gave strength with lightness, produced drag which inhibited attainment of the potential benefits of increased power. A number of designers took advantage of the development of corrosion resistant aluminium alloys, and a better understanding of structural and aerodynamic design, to develop cantilever (i.e. unbraced by external struts and wires) monoplanes.

April 1931 saw the first flight of the Boeing B-9, a monoplane twin-engined bomber, which had the additional innovation of a retractable undercarriage. This aircraft did not go into large scale production.[67] It was soon followed by the similar Martin B-10 bomber, which was ordered in quantity for the United States Army Air Corps in 1933.[68] Soon after 1930 cantilever monoplanes entered

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66 Fairey, page 574

67 Swanborough, G. & Bowers, P.M., United States Military Aircraft since 1909, 1989, page 101

68 ibid., page 433

airline service in the United States, the Boeing 247 in 1933 and the Douglas DC2 in 1934.[69] Air Vice Marshal A.M. Longmore observed that these, "Big, Heavy [sic] passenger carrying monoplanes in America have a speed which is little less than our fighters at the present day".[70]

The Air Ministry had purchased the 1922 Schneider Trophy winner (Supermarine Sea Lion II) and supported the British entries of 1925 - they were designed for high speed research and development and lent to the manufacturers for racing.[71] The RAF staffed and managed the British Schneider Cup team in 1927, 1929 and 1931 and, as will be seen, continued to fund high-speed aircraft research after 1931. The Air Ministry was not unaware of aviation developments in America. It considered buying a Martin B-10 bomber,[72] and, after a visit to the USA by the Director of Technical Development in 1934, generated an "Americanised" version of heavy bomber Specification B.3/34 (see chapter 7). Gunston refers to pressure from the Air Ministry on Bristols to buy a Northrop 2-L aircraft as a test bed for the Bristol Hercules engine, but also because of the Ministry's interest in the quality and finish of the Northrop's stressed skin construction.[73]

The feasibility of higher maximum speeds led to a conflict with landing-speed requirements. A relatively small wing area (or more correctly, high wing-loading) was sufficient and desirable at high speeds, but would inevitably lead to a high landing speed, especially at a time before high-lift devices such as slots and flaps were in general use. This was a particular problem for RAF fighter development because of the requirement that the standard fighter should have a day and night operational capability.

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[69] Linden, F. Robert van der, The Boeing 247: the First Modern Airliner, 1991

[70] PRO: AIR 16/305, Study of Air Fighting Tactics at Northolt, 99A, Enclosure B, Longmore to C-in-C Inland Area, 1st May 1934

[71] Buchanan

[72] PRO: AIR 2/729 Heavy Bomber Specification B3/34. Type Requirements, CAS to Secretary, 7.6.34

[73] Gunston, By Jupiter, page 74

Safe night flying required a low landing speed. This was not a problem when fighters had a low wing-loading so as to give a high rate-of-climb, and when maximum speeds were around 150 mph.[74] But when it became possible to attain much higher speeds, the design conflict with a low landing speed became a significant issue. For a similar reason, when the speed and military and fuel load sought for bombers were much increased in the mid-1930s, the consequent increase in wing-loading made take-off a critical design factor. It is shown in chapter 8 that this led to a planned reliance on catapult take-off, although in practice it meant the acceptance of longer and longer take-off distances. In 1940 this problem was eased by the decision to build concrete runways to replace the grass airfields commonly in use up to then.

The trend to streamlined aircraft led to another complication. They had a flat gliding angle such that when landing the gliding distance from a height of fifty feet could be twice that of the ground run.[75] This led to the practice of specifying landing distances rather than landing speed.

3.4.5 Comparisons of Performance

It is the nature of the subject of this thesis that many references are to aircraft performance data - speed, range, bomb load etc.. It was in those terms that the Air Ministry expressed and discussed its operational requirements. Occasionally reference is made to data from other sources, or to the performance actually achieved by aircraft designed to meet Ministry requirements. All such data, from whatever source, must be viewed with caution and comparisons drawn with great care.

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[74] PRO: AIR 20/167, Development of Fighter Planes. Jan. 1925 - Oct 1940, FO1 to DDOI, 2.7.27

[75] 20/82, FO1 to DCAS, September 1933

A common source of misunderstanding is to overlook the fact that aircraft performance characteristics are inter-related, so that it is meaningless to quote maximum speed, maximum range and maximum bomb load as if they could be obtained simultaneously. This is a common practice of writers who criticise the actions of the Air Ministry between the wars. For example, Robertson claims that "Specification B.9/32 required a minimum bomb load of 1000 lbs. and a range of 1500 miles."[76] It will be shown in chapter 7 that the specification actually called for a normal bomb load of 1,000 lbs with a range of 720 miles. A reinforcing range of 1,500 miles, with no bomb load, was later added to the specification. M. Smith confuses the range and bomb load requirements of the heavy bomber (B.12/36) specified in 1936.[77] He mistakes the operational range of 2,000 miles required for war with Germany with the overseas reinforcing range (3,000 miles), and overlooks that these, and the maximum "warload", were associated with different take-off assumptions. In particular the maximum bomb load was dependent on catapult take-off, which - contrary to Smith's assumption - was not expected to be available overseas. These aspects are discussed in chapters 8 and 9.

To a lesser degree the RAF made errors of this kind with respect to its own aircraft. For example, when it was found that the production model of the Bulldog fighter did not achieve the same maximum speed as had the prototype, it was discovered that acceptance trials had been made without the full military load.[78] A similar error was made with the Hart bomber.[79]

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[76] Robertson, S., page 62

[77] Smith, M., page 237

[78] PRO: AIR 2/346, Type Requirements of Bulldog II Single Seater Fighter Aircraft, RDA3 to ADRDA, 13.7.32

[79] PRO: AIR 2/818, High Performance Day Bomber Spec 12/26. Hawker "Hart" and "Hind". Type requirements. Spec 7/34, CAS to AMSR, 12.12.30

Even if trials had been properly conducted, there was likely to be a difference between the performance of a well-maintained prototype and that of aircraft in squadron service. In 1939 Dowding wrote that he had, "recently been carrying out some experiments, designed to determine the actual speeds of Hurricane and Spitfire aircraft in Squadrons, as distinct from the speeds which are attributed to them by the Air Ministry." He said that his experiments showed that the speed of the Hurricane was seriously over estimated and that the Spitfire was even more disappointing.[80]

Attempts to trace trends over time in the performance required and achieved by RAF aircraft also face the fundamental problem that definitions were changed. Key events were the redefinition in 1932 of bomber cruising speed and range, and of fighter endurance, and further changes in the definition of fighter fuel requirements in 1935, and of bomber performance in 1936 and in 1938.

Before 1932, except for night bombers, it had been common to define maximum speed, range and endurance at full throttle. Estimates of maximum speed continued to be based upon full throttle for both fighters and bombers,[81,82] but in 1932 a new scheme was introduced for specifying the endurance of fighters, and the range and complementary cruising speed of bombers. These were to be based upon the lower power-setting of maximum permissible engine revolutions (rpm) for continuous running.[83,84]

In 1935 there was a complete reappraisal of endurance and other fuel requirements for fighters which had important

80 PRO: AIR 2/2822, Type Requirements for Specn F 36/34. (Hawker), 38A, AOC-in-C Fighter Command to Air Ministry, 25th July 1939

81 PRO: AIR 2/2744, Multi-engined Day Bomber; Type Requirements - Spec. B.9/32, CAS to AMSR, 7.9.32

82 PRO: AIR 2/2821, Whirlwind Single Engined, Single Seater Day and Night Fighter, Specn F/37/35 Type requirements, 2A

83 PRO: AIR 2/2815, Single Seater - Low Wing Monoplane (Bulldog Replacement) Type Requirements Specn. F.7/30, F01 to DTD, 7.10.32

84 2/2744, DTD to DCAS and AMSR, 22.8.32

policy implications. This is fully discussed in chapter 5.

In chapter 8 it will be seen that in 1936 the power setting for bomber cruising performance calculations was reduced to two-thirds of that for maximum power. The Air Staff also reduced the fuel allowance for take-off and emergencies from ½ hour to ¼ hour. Then in 1937 the use of two-thirds maximum power for cruising performance assessment was replaced by the adoption of "maximum economic cruising power".[85] This was the highest power which could be used with a weak fuel/air mixture. For supercharged engines on 87 octane petrol it was said to give approximately 87% of the top speed of an aircraft at 15,000 feet.[86]

In 1938 the Air Staff reviewed the provision that was made for reserves in the calculation of the effective operational range of bombers, and found that Bomber Command used a different approach from that used by the Air Staff.[87] The then Deputy Director of Operational Requirements (Group Captain R.H.M.S. Saundby) proposed a new scheme to be used for all purposes.[88] In this, before the still air range at maximum economic cruising power was calculated, fuel was to be set aside for 50 minutes at that power. This was to allow for taxying and take-off, climb at full throttle, and ½ hours flying to allow for navigational errors and other emergencies. Any additional allowances for operational reasons were to be decided by the officer planning each mission.[89] These rules were approved by the CAS,[90] and incorporated into Air Staff

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85 PRO: AIR 2/2833, Tornado and Typhoon. Single Seater Fighter - Specification F18/37 - Type Requirements, RDA3 (Liptrot) to DDOR, 26.7.37

86 PRO: AIR 8/231, Aircraft Performance Figures 1937-45, AMRD to PS to CAS, 4.2.38

87 PRO: AIR 2/3318, Effective Operational Ranges of Aircraft, DDOps to DDOR, 14.6.38

88 ibid., DDOR to ACAS, 9.7.38

89 ibid., Appendix 10A, Ranges of Aircraft

90 ibid., CAS to ACAS, 12.7.[38]

operational requirements for new aircraft, albeit in a slightly different form.[91]

This comprehensive scheme did not last long. In March 1939 the Director of Operations explained to the DCAS that effective operational range and corresponding bomb lift was calculated by taking a typical operation, and assuming the highest cruising speed over a defended area, economical cruise over the sea, and a period of maximum power if engaged.[92]

The important point about the series of changes in the definition of speed and range described above is that they were applied retrospectively to existing types. In consequence, other than for maximum speed, it is seldom possible to directly compare the performance data specified in an operational requirement with that calculated for the resultant aircraft during its development and when it had entered service. Furthermore, apart from changes in definition, during the course of the design and development of an aircraft other factors arose. In general improvements in engines led to the potential for a higher performance than that first sought, but this could be more than offset by weight increases and other departures from the design as first envisaged. In addition, as will be seen in chapters 8 and 9, the acceptance in the late 1930s of increased take-off and landing distances had a very marked influence on attainable performance.

The cumulative effect of many of these factors is illustrated by the history of the Vickers Wellington. It is shown in chapter 7 that the operational requirement which led to this aircraft was conceived in 1931, and included a planned range of 600 miles at full throttle (190 mph) with a bomb load of 1,000 lbs. The change in

[91] PRO: AIR 2/2958, Bomber Landplane to Spec. No. B1/39. Type Requirements., OR1 to RDA3, 22.7.38
[92] 8/231, DOps to DCAS, 23.3.39

the definition of range in 1932 led to the specification being issued with a range of 720 miles at maximum continuous rpm (170 mph). Development was much delayed, and design changes were made before the prototype first flew in 1936. In August 1937 a comparison was made of the expected performance under normal take-off conditions of the medium and heavy bombers then under development, and the Wellington was now credited with a range of 1,550 miles at 214 mph with a bomb load of 2,000 lbs.[93] Early in 1939 it was credited a range of 1,425 miles with a bomb load of 4,500 lb - but these figures assumed a very long take-off and not normal conditions.[94] It had been found that the geodetic structure of the Wellington was over strength, and it was therefore best judged on overload performance.[95]

Performance estimates for the aircraft designed to the 1936 heavy bomber specification B.12/36 illustrate the expectations which could be raised during design - expectations which, as shown in chapter 9, could then be translated into unattainable performance demands for the next generation of aircraft. The Air Staff Requirement issued in July 1936 called for a top speed of 275 mph at 15,000 feet, but in 1937 there were estimates of nearly 330 mph for both the Short and Supermarine designs to B.12/36.[96] Thereafter estimates for the Short Stirling decreased,[97,98] and acceptance trials early in 1941 found the top speed at 15,000 feet to be only 218 mph[99] - less than the original call for a cruising speed of 230 mph.

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93 9/82, 12A, 26.8.37

94 PRO AIR 2/1964, Wellington Vickers Bomber to Specification B.9/32. Type Requirements, 7A of 55A, note by OR2, 15.2.39

95 8/231, AMRD to AMSO, 18.12.36

96 PRO: AIR 2/2082, Consideration of Design of Experimental Heavy Bomber included as a Development Type in the 1937 Estimates. Specn. B25/37, 5A, RDA3 to DTD, 12.11.37

97 8/231, CAS to AMDP, 20.3.39

98 ibid., Table dated 2.5.39

99 PRO: AIR 2/2899, Short Bro's. - Stirling Landplane B12/36. Type Requirements and Summary of Trials, 53A

An additional problem arises in making international comparisons, for there were different conventions for describing engine characteristics. For instance, in 1938 the Chief of the Air Staff queried data which showed that the cruising speed of RAF fighters was a much lower percentage of maximum speed than those of other countries.[100] It was explained to him that the apparent inconsistency arose because other countries used a different system of engine rating.[101]

The discussion above illustrates how difficult it is to make valid comparisons of aircraft performance, yet the problems outlined above appear to have gone unnoticed in the literature, where it is common to quote what can best be described as a random collection of data obtained from specifications, design estimates, prototype trials and performance in service, with no indication of date or of other relevant factors. An example is a Table compiled by Robertson which he says "illustrates the trend in Air Staff *specifications*".[102] It gives data for bombers from 1920 to 1940. Most of it is unrecognisable when compared with that given in the actual specifications - which can readily be found in the primary sources.

In the current research the intention is to explore the performance that the Air Staff were seeking, and why. It will therefore be concerned primarily with estimates made at the inception stage of new aircraft, and hence with the definitions ruling at that time. Attention will be drawn to instances where a change in the definition of performance was relevant to the consideration of an operational requirement.

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[100] 8/231 ibid., CAS to DCAS, 31st January 1938
[101] ibid., AMRD to PS to CAS, 4th February 1938
[102] Robertson, S., pages 65-66, italics added

4. DEVELOPMENT OF OPERATIONAL REQUIREMENTS: 1923 to 1930

4.1 INTRODUCTION

Chapters 2 and 3 have discussed how a number of political, strategic and technical issues had an important bearing on the characteristics of the aircraft with which the RAF sought to carry out its home defence responsibilities. This chapter deals with the way in which the RAF's thinking on operational requirements in the 1920s developed against that background.

The aircraft which actually came into service with the RAF during the 1920s were in response to requirements which sought no more than a gradual improvement over the types with which it had finished the war in 1918. Some remained in service for many years. For example, the Vickers Virginia night bomber served, albeit much modified, from 1924 until 1937,[1] and versions of the Armstrong Siddeley Siskin III fighter equipped first-line fighter squadrons from 1924 to 1932.[2] Nevertheless, behind this traditionalist appearance there was much discussion on the best type of bomber, on defence against a formation of bombers, and above all on defence against air attacks on London. None of the more extreme ideas which were put forward led to aircraft which entered service, but towards the end of the decade the Air Ministry initiated major advances in the RAF's fighter aircraft and their armament which prepared the ground for the great advances made in the 1930s.

Paradoxically, a Service devoted to the principle of offensive bombing operations put more effort into the development of fighter aircraft than it put into the

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1 Thetford, O., Aircraft of the Royal Air Force, 1988, page 539

2 ibid., pages 22 and 24

development of bombers. This policy is noted in the Air Historical Branch narrative on the evolution of Bomber Command, where it is said that, "the Air Ministry devoted most of the scanty sums available for scientific and technical research to experiments designed to improve the defensive rather than the offensive power of the A.D.G.B, forces".[3]

The AHB narrative says that although concentration on defence as a long-term policy (which, it says, in the event proved correct) may appear a "curious policy to pursue at a time when the doctrine of the offensive was still the accepted gospel", it was justified by the ten-years rule. This is a surprising deduction, for in most businesses the expectation of no major change in the market for ten years ahead would be seen as a reason for embarking upon long-term research relevant to making the core business more competitive. The RAF undoubtedly saw its core business as bombers and bombing. Moreover, despite the effort that was put into fighter development, the RAF did not believe that it had succeeded in producing an adequate defensive system, either during the reign of the ten-year rule or afterwards.

Robertson and Mason put forward the opposite conclusion to that of the Air Historical Branch. Robertson asserts that the Air Staff neglected fighter technology, and that only in the mid- to late-1930s were they "forced to consider fighters in a meaningful way".[4] Mason, in discussing Trenchard's influence on RAF equipment, claims that he aimed to,

> keep the bomber at the forefront of technology by means of a constant stream of prototypes. Moreover, the research necessary to ensure this advance would become the responsibility of the privately-owned industry. Thus the bomber made slow technological progress within the funds available, although, by implication, the interceptor fighter - the logical

[3] 41/39, page 35

[4] Robertson, S., pages 67-68

> instrument with which to gain major advances ... was permitted to stagnate.[5]

This is a confused argument, which at best implies comparison with some technological ideal of the kind noted in section 1.2.1 above. Mason contradicts his claim that interceptor fighters were permitted to stagnate under Trenchard in his The British Fighter, where he writes favourably of the Hawker Fury fighter[6] - which, as will be shown, was developed at Trenchard's instigation.

When this issue of whether or not the RAF put more effort into the development of fighters or bombers is viewed in terms of the operational requirements which the Air Staff sought, rather than in terms of the aircraft which industry produced, it will be seen that there was some complacency regarding bombers, which contrasted with a more thoughtful and innovative analysis of the role of fighters.

This chapter first discusses the general development of operational requirements for fighters and bombers in the 1920s, and then describes the evolution of some types of aircraft which were important as stepping stones to the operational requirements of the 1930s. This is followed by an analysis of the testing of some aspects of the operational effectiveness of the aircraft developed in the 1920s in the RAF's Air Exercises of 1927-1932. Finally there is a review of the position reached by the end of the 1920s.

4.2 AN OVERVIEW OF THE 1920s

In chapter 3 it has been seen that responsibility for the formulation of the RAF's operational requirements was fragmented in the 1920s, and indeed remained so up to

[5] Mason, The British Bomber, 1994, page 117
[6] Mason, The British Fighter, 1992, page 213

1934. This may be why the author has found no record of an analysis of the RAF's operational requirements as a whole which can be dated earlier than 1928. On 1st March of that year Wing Commander W.L. Welsh lectured to the RAF Staff College on "Air Staff Requirements in Aircraft".[7] Welsh was then head of Flying Operations 1 which, as explained in chapter 3, was the section of the Air Staff which had become responsible for formulating operational requirements. His review brought together the whole range of the RAF's operational responsibilities. The two copies of the lecture which are held in the Public Record Office are unsigned and undated, and the present author is grateful to Mr. Peter Elliot of the RAF Museum for identifying the lecturer and occasion. Welsh's review is taken here as the framework for a general discussion of the development of operational requirements in the 1920s, with reference to earlier studies as appropriate, and particularly to the thought-provoking views of Air Commodore J.A. Chamier.

Chamier was Director of Technical Development at the Air Ministry prior to his retirement from the RAF in December 1928, when he became Secretary-General of the Air League. In November 1928 he sought permission to publish a paper on "Air Bombardment". Chamier wrote,

> The object of this note is to examine the present problem of air bombardment, the tactics of day and night bombing aircraft and the methods which may be adopted by the defence.[8]

His views on operational requirements differed from those of the Air Staff, and although publication of his paper was refused, Chamier's ideas were taken seriously. His paper was copied by the DCAS to a number of senior officers with the comment that it "has at least the merit of venturing off the beaten track", and a request for "how

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[7] 9/37, Folio 10, Air Staff Requirements in Aircraft,

[8] 5/1132, File 18, 1A, Chamier to Air Ministry, 5th November 1928: Air Bombardment, page 1

your views on the broader aspects of the problem compare with those of the writer of the essay."[9] Chamier's views and those of his critics are noted below as appropriate and contrasted with the Air Staff's assessment of operational requirements.

Welsh's lecture on "The Air Staff's Requirements in Aircraft" first considered the RAF's duties throughout the British Empire, the need for economy, and the ever changing state of aircraft development. It then turned to the issue of priorities, stating that,

> The Home Defence problem .... is the most difficult to meet, and at the same time the most vital. If the needs of Home Defence can be met, it is probable that the machines in it can be adapted to meet the other and less difficult demands from overseas. It would be illogical to start the other way round and to build machines eminently suited for the different overseas commands, which would at best be indifferent Home Defence machines, if only for the reason that while we were adequately protecting our outposts, the heart of the Empire for its safety would depend on makeshifts.[10]

This comment contradicts the assertion by M. Smith that the RAF under Trenchard (CAS 1919-29), "was organised and equipped primarily to deal with the typical peacetime problems of the British Empire".[11] As Ferris observed, "Contrary to Smith's account, in 1922-25 the RAF sought above all else to create strategic bombing forces."[12]

Clearly, as regards equipment, the aircraft needed for home defence were seen as the first priority. Indeed, following agreement to the Home Defence Expansion Scheme in 1923, Trenchard held a meeting on policy at which, "He reminded those present that our difficulties in regard to the day bomber were the natural consequences of the policy

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[9] ibid., DCAS to AVMs Scarlett, Steel, Brooke-Popham, Dowding, Air Commodores T.C.R. Higgins and Ludlow-Hewitt, 12.3.29

[10] 9/37, Folio 10, page 3

[11] Smith, M., page 13

[12] Ferris, J., "The Theory of a 'French Air Menace', Anglo-French Relations and British Home Defence Air Force Programmes of 1921-25", <u>JSS</u>, Vol 10 (1987), No.1, page 63

of the last three years." He said that the ten-year rule had then led to the production of a "'general utility' machine for use in Iraq and elsewhere." Trenchard now specified the day bomber which he saw as needed to attack Paris, and, accepting that this would take time to develop, said that meanwhile "preference in equipment would now be given to fighter and night bomber units".[13] Yet Smith suggests that,

> The work of the RAF in the 1920s required equipment which would be no use at all in a European emergency. In hot and undeveloped countries, where there was no aerial opposition, lift, flight stability, low landing speed, ease of repair and fuel economy were the factors which governed the design of aircraft.[14]

Smith does not indicate which of these factors might have been dispensed with for aircraft designed for a European war. Certainly none is dependent on the absence of aerial opposition. All aircraft require lift and flight stability, the night operation of home defence aircraft required a low landing speed, and ease of manufacture, repair and maintenance were sought for all RAF aircraft. It therefore should come as no surprise that the aircraft developed for European operations were suitable for the RAF's overseas Commands. Omissi refers to the claims of other writers that policing operations influenced RAF aircraft requirements and strategy,[15] but concludes that the use of obselete aircraft in this role did not retard the development of new types for home defence.[16] Indeed, most of the aircraft used for air control in Iraq and elsewhere in the 1920s were the Bristol F2B and DH9A of 1914-18 war vintage.[17]

Nevertheless, the view has persisted that Air Control considerations dominated RAF aircraft development between

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[13] 20/84, Requirements for the New Day Bomber. Explanation of requirements and policy by C.A.S., 2.8.23

[14] Smith ibid, page 32

[15] Omissi, D.E., Air power and colonial control, 1990, page 134

[16] ibid., page 210

[17] Bowyer, C., RAF Operations 1918-1938, 1988

the wars. In the 1997 Brabazon lecture the Chief of the Air Staff said that as a result of such "low intensity" operations there was "no great incentive to push airframe, engine and weapon technology", and that "between 1939 and 1942, we paid a heavy price, almost a fatal one, for that preoccupation with low intensity, low technology operations".[18] It will be shown that in fact the needs of Air Control operations played no part in the operational requirements which led to the home defence aircraft used by the RAF in those years.

In 1928 Welsh listed sixteen classes of aircraft required by the RAF.[19] None was specifically for Air Control duties. The sixteen classes were:-

(a) Land Single Seater fighter.
(b) Land Single Seater fighter (interception).
(c) Ship Single Seater fighter.
(d) Multi-Seater fighter (C.O.W. gun experimental tactically).
(e) High performance day bomber.
(f) Medium performance day bomber.
(g) Night bomber.
(h) Giant night bomber.
(j) Land Torpedo Bomber.
(k) Ship's Torpedo Bomber.
(l) Fleet Spotter Reconnaissance.
(m) Coastal Reconnaissance.
(n) Army Co-operation.
(o) General Purpose Bomber Reconnaissance for overseas.
(p) Submarine Co-operation.
(q) Training.

The classes relevant to the home defence force were the fighters (a), (b) and (d), and the bombers (e) to (h). Welsh said that there was a consensus of opinion that two other fighter types might be added, a two-seat fighter and a night fighter.

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18 Johns, ACM Sir Richard, "Air Power", JRAeS, Vol 25, January 1998
19 9/37, Folio 10, page 3

4.2.1 Fighter Requirements

The requirement for two Land Single Seater Fighters can be traced back to the basic principles of the 1923 Home Defence Scheme, which have been explained in chapter 2.3.3, and are re-capitulated below.

Fighters of class (a) were stationed in the Aircraft Fighting zone. They were to take-off at the first sign of an attack and climb to pre-determined patrol lines, from which they would be directed by radio to intercept incoming enemy aircraft. This was the main system for the defence of London. Interception fighters (class(b)) would operate by day only. They were not required to carry radio equipment and had less endurance than zone fighters. Clearly, a zone fighter could serve as an interception fighter, but not *vice versa*, and it was some years before a pure interception fighter operational requirement and specification were issued. This is discussed in section 4.3.2 below. Meanwhile, interception fighter squadrons were equipped with zone fighters.[20]

4.2.1.1 Zone Fighters

The question of the best type of aircraft to fulfil the home defence zone fighter role concerned the RAF throughout the years between the wars. There were seen to be two major issues, one a genuine consequence of geography, and the other flowing from the RAF's confidence in the fighting strength of its own, and therefore an enemy's, formations of bombers.

The geographical problem resolved into a question of response time. Warning of an attack could not be obtained before hostile aircraft were seen, or maybe heard, approaching the English coast, and this would leave little

[20] 2/794, DCAS to CAS, 27th May 1927

time for interception before they reached London. For example, if the enemy was flying at 10,000 feet at 100 mph they would reach London in about 30 minutes after first being detected. In that time defending aircraft would have to be manned, have their engines started and warmed up, take-off, climb to the height of the raiders, intercept and destroy them. The Staff Exercises of 1931 included exactly this type of calculation to decide where to base the fighter defence of Newcastle against attack from "enemy" forces based in East Anglia.[21]

Clearly as the speed and altitude attainable by bombers increased, so the prospect of solving the problem of defending London against air attack became remote. This was summed up in the 1928 review by the comment,

> As is well known, the main problem of the defence of London is time; and experience in the Air Defence Command has shown that no Fighter so far produced, good as it may be, is good enough.[22]

It was the problem of response time which led the RAF to seek single-seat fighters with a high rate-of-climb. Indeed, some saw such aircraft as unique to the defence of London. In replying to comments from the Commandant of the Imperial Defence College on what he described as the RAF's doctrine of "Air Offensive at All Costs", Sir John Salmond (CAS from 1st January 1930) explained that,

> we shall very likely always have to have S.S.F.'s [single-seat fighters] for our one specialised problem, the defence of London, where the time factor is everything. This I believe is the only sole reason for their existence; The French - no one else, in fact, except possibly some day Germany with the Ruhr - have not the same problem [sic][23]

Even so there were strong doubts as to whether single-seat fighters would be effective even if they did succeed in

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21 PRO: AIR 9/64, Folio No.2, Air Ministry Staff Exercises No. 2 (1931), 22.5.31

22 9/37, Folio 10, page 7

23 9/8, Folio 34, JLS[almond], 24th March 1930

intercepting hostile bombers. There was little experience from the 1914-18 war of combats between formations of heavy bombers and defending fighters, but quasi-theoretical analyses of the problem led to a long-running search for an alternative type of home defence zone fighter.

4.2.2.2 Multi-Seat and Heavy-Gun Fighters

The concept of a multi-seat heavy-gun fighter, the fourth fighter type in Welsh's list, was first put forward by Air Commodore T.C.R. Higgins when he was Director of Training and Staff Duties in 1923.[24] Higgins examined the problem of defence against formations of bombers based upon an analysis of the Gotha bomber raid on London on 7th July 1917.[25] In fact this raid was not intercepted, but Higgins assessed the likely results if it had been intercepted by a squadron of single-seat fighters. He concluded that they would have been ineffective because of the ability of a formation of bombers to concentrate its fire on a series of fighter attacks. This advantage was thought to be enhanced because of the belief that a "free" gun mounted in a bomber was inherently more accurate than the fixed guns of a fighter.

Higgins stated that "All experience proved that the ability to fight offensive actions in Squadron formation was vital to the defence."[26] - a view which influenced consideration of fighter design and tactics for many years. He deduced that what was needed was a type of fighter which could manoeuvre in formation alongside a formation of bombers and engage them broadside - somewhat on the lines of a traditional naval battle.[27] Higgins proposed a twin-engined fighter armed with heavy guns.

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[24] 2/1069, 1A, 6th March 1923
[25] ibid., DTSD to AOC Inland Area, 6th March 1923
[26] ibid., page 3, para 10
[27] ibid., page 4, para 17

Higgins' paper was widely circulated for comment in the RAF. His conclusions were supported by a separate study made by a committee on behalf of the Air Member for Supply and Research,[28] but many others criticised them. Foremost amongst these were the staff of the RAF Staff College, who argued that German single-seat fighters had been effective against deep penetration raids by the Independent Air Force in 1918,[29] a view which is supported by the Official History of those raids.[30] Another critic was the chairman of the AMSR's committee. He put in a minority report in which he argued that if a large fighter could not be guaranteed to have a gun of greater range than the enemy it would be useless.[31]

Despite these doubts, Trenchard supported[32] the building of two prototype twin-engined heavy-gun fighters to specification 4/24 - the Westland Westbury and the Bristol Bagshot. The intention was to experiment with the Coventry Ordnance Works (C.O.W.) 1½ pounder (37mm) gun and the tactics of its use. Both aircraft were unsatisfactory as fighters, but the Westbury was used for many years as a test bed for the C.O.W. gun.[33] A second C.O.W. gun fighter specification (F.29/27) was issued in 1928.[34] Prototypes to this single-seat fighter specification were built by Westlands and Vickers.

Postan's reference to these episodes is an illustration of the danger of not looking for the origin of new developments, and hence attributing them to industry. He says that,

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28 9/37 Folio 11, Design of Home Defence Fighting Aeroplane, undated and unsigned, c.1923

29 2/1069, Commandant, RAF Staff College, to Air Ministry, 6th April 1923

30 Jones, H.A., The War in the Air Vol VI, 1937, pages 118-174

31 9/37 Folio 11, Minority Report

32 2/1069, CAS to AMSR, 10.4.24

33 Mason, T., British Flight Testing, 1993, page 114

34 PRO: AIR 2/347, Type Requirements for C.O.W. Gun Fighter Spec. F.29/27, dated 1st March 1927, but from accompanying minutes 1928 is obviously correct.

> As an experiment, Westlands had actually installed a 37 mm. gun in a fighter as early as 1927, and Bristol's also claim to have been interested in the installation of large guns. But at the time neither the guns nor their installation were such as to justify a change in the Air Force tactics *or in Air Ministry specifications.*[35]

In "Air Bombardment" Chamier concluded that single-seat heavy-gun fighters were the correct counter to both low-flying fast day bombers and to formations of high-flying heavy day bombers. His argument was that a heavy gun would be needed for long-range firing in a stern chase against fast bombers, and to stay out of range of the machine guns of a heavy bomber formation. In their comments on Chamier's paper, Air Commodores E.R. Ludlow-Hewitt[36] and T.C.R. Higgins[37] (as expected) favoured some sort of heavy gun fighter, but in addition to rather than instead of existing types. Both Higgins and AVM Sir Robert Brooke-Popham agreed with Chamier that manoeuvrability was not an essential requirement for a home defence fighter. Brooke-Popham wrote,

> I do not consider that it is essential for a home defence fighter to have the same degree of manoeuvrability as was found necessary in France in the last war because the home defence fighter will normally be operating only against enemy bombers[38]

The remaining two types of fighter considered in the 1928 review of requirements were a two-seat fighter and a night fighter. The concept of a two-seat fighter was dismissed on the grounds that the proposed attack tactics were unfeasible and that a "back gun" (a traditional feature of a two-seat fighter) was essentially a defensive weapon which should not be needed in a fighter. Welsh firmly stated that therefore a two-seat fighter was not being developed, with the comment that, "it has not yet been possible to produce even a Single-Seater Fighter with

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[35] Postan, page 108, italics added

[36] 5/1132, Ludlow-Hewitt to DCAS, March 1929

[37] ibid., Higgins to DCAS, 3.4.29

[38] ibid., Note on Air Bombardment, Brooke-Popham, 6th May 1929, para.6

sufficient performance."[39] It will be seen in section 4.3.3 below that in less than two years the RAF decided to experiment with a two-seat fighter in the mistaken belief that this would be faster than a single-seat fighter.

4.2.2.3 Night Fighters

That there was a *prima facie* case for a specialist night fighter was accepted by the Air Staff in 1928, for it was known that the clear view forward and upward that was essential for night fighting could not be obtained from a tractor-engined biplane.[40] This was also evident to operational pilots.

In 1924 the fighter squadron pilots of No. 6 Group had advocated the development of a pusher-engined single-seater (with the pilot seated ahead of the wings and engine) so as to get a good view for night fighting.[41] In 1926 the ADGB Command put forward a similar proposal.[42] It noted that even though the Woodcock (a contemporary zone fighter) was a good night flyer, it was a bad night fighter because of an indifferent view. The Air Staff's response on both occasions was that the loss of performance associated with a pusher configuration would be too great and would detract from the fighter's use by day. They claimed that most of the advantages of a pusher could be obtained from small twin-engined aircraft, and that a prototype of this kind was being developed; trials would show if this approach was the answer.[43] The aircraft referred to in 1926 was the Boulton & Paul

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[39] 9/37 Folio 10, page 4

[40] ibid., page 5

[41] PRO: AIR 2/269, Use of Pusher Type Fighter Aircraft for Home Defence Work, Commander No.6 Group to Headquarters Inland Area, 2nd September 1924

[42] ibid, AOC-in-C ADGB to Air Ministry, 9th July 1926

[43] ibid, DDOI to AOC Inland Area, 26th November 1924 and DDOI to AOC-in-C ADGB, 4th August 1926

Bittern, whose trials were not satisfactory and which was not developed further.[44]

In the absence of a specialist night fighter, zone fighters were required to operate by night, despite doubts about their effectiveness, and in some cases their safety.[45,46] They were required to have a low landing speed (52 mph as compared with 65 mph for a day only interception fighter),[47,48] and to carry night flying equipment and radio - in the late-1920s these accounted for nearly 20% of the military load of a fighter.[49] A fighter designed without these restrictions could be expected to have a considerably higher performance than a comparable zone fighter.

Thus the policy of requiring a day and night operational capability for the RAF's standard fighter led to aircraft which were recognised as inadequate night fighters and were less than the best possible day fighters. In chapter 5 it is shown how the issues of view and landing speed dominated discussion of the operational requirements for the next generation of zone fighters, and confirmed Welsh's comment that "the best Fighter is like the carrot dangled in front of the donkey's nose - it is never reached."[50]

4.2.2 Bomber Requirements

Four types of bomber were listed in the Air Staff review of 1928: high-performance day, medium-performance day, night and Giant. Development of a Giant bomber was said

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44 ibid, AMSR to CAS, 7.5.28

45 5/564, First Meeting of A.A. Defence Committee, November 1921, Group Captain Higgins' remarks

46 2/2815, DTD to DCAS, 13.8.30, and DCAS to CAS, 10.11.30

47 2/346, Specification No. 9/26

48 2/794, Specification No. 20/27

49 PRO: AIR 2/1238, Consideration of a Two Seater Fighter, Liptrot to AD/RDA, 8.5.30

50 9/37 Folio 10, page 7

to be "dormant".[51] It appears to have last been considered in 1922 in the context of a joint bomber/civil transport.[52] In the late 1920s there was some initiative from industry which is described later in this chapter.

4.2.2.1 Day Bombers

In 1928 day bombers were divided into two classes, high performance and medium performance. This distinction was brought about by the advent of the Fairey Fox in 1925,[53] with its much higher performance than the day bombers then in service. High-performance bombers were seen as relying primarily on evasion for defence, being difficult to intercept because of their speed. It was said that they were cheap, but had a light bomb load, short range, and could operate only by day.[54]

Chamier's view of high performance day bombers was more positive than the Air Staff's. He believed that unless a satisfactory heavy day bomber could be developed, they were the only bombers left "to continue the struggle against the re-armed defence and theirs is no easy role. What is their logical development?" His answer was that as their defence lay in speed and not in gunpower, the gun and gunner should be sacrificed for greater speed. He foresaw a fast single-seater with a bomb load no greater than the gun and ammunition load of a fighter, and therefore with a comparable performance. He claimed that,

> Against these changeling bombers the [heavy] gun carrying defender becomes useless; in his turn he must revert to a normal fighter getting his superior performance by his lessened endurance.[55]

51 ibid., page 13
52 5/955, Director of Research's Programme 1923-24: Conference on 6th October 1922
53 20/84, Summary of Tenders to Specification 12/26, 28.2.27
54 9/37 Folio 10, page 12
55 5/1132, Air Bombardment, page 12

It will be recalled that Chamier had proposed "heavy-gun" fighters to combat two-seat day bombers, but he expected that his proposed single-seat day bombers would outpace such fighters. He had thus raised the issue of a "speed bomber" as it came to be known, and, unwittingly, the use of fighter-bombers as arose in the Second World War.

In their comments on Chamier's paper Ludlow-Hewitt and Higgins made what were to become the standard policy objections to proposals for an unarmed bomber which relied solely upon speed for its safety. Ludlow-Hewitt's criticism was based upon the morale of pilots, who if caught would be "dead meat".[56] Higgins argued that the production of a fast light bomber could not be kept secret, and that faster fighters would be produced.[57] Strangely, there is no record that when in 1923 Trenchard asserted that high altitude would confer immunity on day bombers,[58] this was countered by the similar suggestion that high altitude fighters would be produced.

Class (f), the medium performance (not medium bomb load) day bomber was represented in 1928 by the single-engined Hawker Horsley and the twin-engined Boulton & Paul Sidestrand; both had been specified before the emergence of two classes of day bomber. The Sidestrand was initially developed to assess the merits of a twin-engined day bomber, which, whilst having a lower performance than a single-engined type, would be able to carry more guns for defence.[59] Its bomb load of 550 lbs and radius of action of 275 miles were little greater than those of the single-engined, high performance, Fox, (460 lbs and 210 miles respectively). Welsh suggested much the same bomb load and range requirements for the replacement of both types.[60]

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56 ibid., Commandant RAF Staff College to DCAS, March 1929
57 ibid., Higgins to DCAS, 3.3.29
58 20/84, Explanation of requirements and policy, 2.8.23
59 9/69 Folio 41, A.D.G.B. Exercises - July 1927
60 9/37 Folio 10, Appendix

Chamier reasoned that the medium-performance class of day bomber would have to carry heavy guns for defence against his proposed heavy-gun fighter, and stressed that, in consequence, gun installations would become a high percentage of the available military load. Chamier saw this as the "germ of our future policy",[61] for it would lead to a large aircraft if the three aims of adequate range, bomb load and defensive capability were to be achieved. Chamier's summation of the future of this class was that "We must expect it to become a great machine".[62] These were prescient remarks indeed, as will be shown in chapters 8 and 9.

4.2.2.2 Night Bombers

Provision for night bombers (class (g)) followed from the 1923 decision that continuous attacks were necessary to obtain the maximum benefit from an air offensive. The 1928 review re-iterated that policy and discussed the requirements of night bombers at some length, taking account of the inter-play between bomb load, range, speed, and the hours of darkness at different times of the year. This latter consideration was important because a slow night bomber could not complete a long-range mission in darkness in a European summer. Welsh concluded that,

> our night bombers, unless they possess very great speed will either be unable to operate at their full radius right throughout the year, or will have to be capable of operating by day as well as by night. The latter alternative is the solution if mobility and continuity in attack are to be maintained.

Welsh foresaw that, "as anti-aircraft defence methods both air and ground, improve, such as the facility with which fighters can find bombers, so will the performance of the

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[61] 5/1132, Air Bombardment, page 12
[62] ibid., page 16

night bombers have to improve". He deduced that there would be a tendency for the characteristics of the night bomber and the medium-performance day bomber classes to merge.[63]

Robertson[64] makes sweeping deductions from these discursive remarks by Wing Commander Welsh; (he is unaware that "Air Staff Requirements in Aircraft" was a lecture to the RAF Staff College). He believes that the prospect of a bomber capable of day and night operation meshed well with a supposed Air Staff "preference for general purpose aircraft", and that,

> had the Air Staff continued with the requirement for a night bomber, which relied upon speed alone to make its raid during the hours of darkness, then perhaps the industry would have made the breakthrough in design and development that was necessary.

He cites the Mosquito - designed eleven years later - as an example.[65]

In fact, within a few years the Air Staff issued requirements which called for bombers with a speed higher than the 173 mph that Welsh had specified as needed to complete a long-range mission in darkness.[66]

Earlier in this chapter Welsh's emphasis that home defence considerations must dominate RAF aircraft requirements is quoted. Nevertheless, in his discussion of Welsh's paper, Robertson pursues the familiar line that the lack of an immediate threat to the United Kingdom meant that "duties throughout the Empire took precedence". He says that should a "more far-flung" threat than that from France arise, "the Air Staff assumed that continuous development in aircraft would allow them to reconfigure the air force to meet such a threat." Yet in Welsh's paper this

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63 9/37 Folio 10, page 11
64 Robertson, S., pages 69-75
65 ibid., page 75, Note 19
66 9/37 Folio 10, page 11

assumption is clearly contradicted, for after noting that existing RAF night bombers could attack Paris in darkness throughout the year, Welsh wrote,

> This it may be argued should be sufficient as the raison d'etre of the home defence force is to defend this country against France. But to accept it would be to immobilise the air force and render it ineffective should the political situation point to operations which call for a greater radius of action.

With this consideration in mind he took the problem of making the return journey to Berlin from Metz or to Samarkand from Kabul (both requiring a design range of about 950 miles) as the determining factor in night bomber requirements.[67]

It is from his interpretation of Welsh's lecture that Robertson concluded (quoted in chapter 1.2.1) that the Air Staff did not understand the complex issues of aircraft development. He added that, "Moreover, it carried with it the unintended consequence of actually restricting the pace of aviation development."[68]

It will be seen from later chapters that these are totally unjustified conclusions, in line with Robertson's own misunderstandings of the complexities of aircraft design, as noted in chapters 1.2.1 and 3.4.5.

4.2.2.3 Feasibility of a Continuous Day/Night Offensive

The problem which faced the Air Staff between the wars was that in the absence of combat experience it was not known whether bombers should depend upon evasion (by speed or darkness) or on self-defence to carry out their missions. It was believed that night bombers would be intercepted and attacked by defending fighters in much the same way as

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[67] ibid., pages 10 and 11
[68] Robertson, S., page 75

would day bombers. This, after all, was why the RAF's zone fighters were required to have a day and night operational capability. Chamier went so far as to suggest that night bombing might become too hazardous.[69] Overall, there was thought to be no particular merit in night bombing - which would be relatively inaccurate - apart from the desirability of having the means to mount a continuous offensive.

Faced with these uncertainties, it has been shown in chapter 2 that the policy adopted in 1923 was to aim to equip the majority of bomber squadrons with a dual-role bomber - which could then operate by day or by night depending on time of year and degree of opposition. The Provisional Scheme's plan for twelve each of day squadrons and night squadrons, with eleven undecided, was intended as a temporary position until a dual-role bomber was developed. Indeed, at the policy meeting in August 1923 discussed above, Trenchard re-iterated that ultimately, "we did propose to have a combined day and night bomber for the majority of squadrons".[70]

However, for many years a dual-role bomber was regarded as technically unattainable. Thus when in May 1924 Plans Branch of the Air Staff considered the equipment of the undecided eleven bomber squadrons, it suggested day bombers - partly because it was easier to train pilots for that role. Plans' most telling argument was that day bombers were cheaper, and easier to maintain, than night bombers because, "they had only one engine".[71]

Later in 1924 Air Commodore J.M. Steel, then DCAS, took a less committed line. In writing to Trenchard on the issue of the proportion of day and night bombers he said that,

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69 5/1132, Air Bombardment, page 6

70 20/84, Explanation of requirements and policy, 2.8.23

71 9/8 Folio 31, The Type of the Remaining 11 Home Defence Bombing Squadrons, Plans, 16.4.24

> Unfortunately there are several factors bearing on the question which we cannot foresee, such as the nature of armament which will be carried in future aircraft, to what extent defensive arrangements by day and night will develop, and whether the war will take place in the summer or winter.

He accepted that whilst operationally it was desirable to have the majority of squadrons able to operate by day and by night, there were training and technical difficulties to be overcome. Therefore for the time being it was Air Staff policy to have a few purely day squadrons, a few purely night squadrons, and the majority indeterminate. Steel said that,

> The apparent vacillation will enable a definite decision to be made when more information is available as to the "dual-role" bomber which is so eminently desirable, and the necessary degree of performance and bomb-load for night-bombers will also be easier to decide.[72]

Such indecision on the composition of the planned thirty-five squadron bomber force has to be viewed against the background of the number of bomber squadrons in home defence service in the 1920s; nine Regular and five Reserve/Auxilary in 1925, ten Regular and eight Reserve/Auxilary in 1930.[73] There were indeed a few purely day squadrons and a few purely night squadrons - and no others. The target of thirty-five bomber squadrons set in 1923 was not achieved before it was overtaken by re-armament in the mid-1930s. Thus "vacillation" could continue for many years.

Less excusable was the incompatibility that arose between the importance attached to continuous, day and night, attacks and the radius of action specified for different classes of bomber. This appears to have gone unnoticed, both at the time and in modern accounts.

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[72] 9/69 Folio 57, Proportion of Night and Day Bombers, DCAS to CAS, 23.6.24, paras. 1 and 4

[73] Moyes, P.J.R., Bomber Squadrons of the RAF and their Aircraft, 1964, pages 298 and 299

Welsh's analysis of night bomber requirements in terms of speed *versus* armament was governed by the requirement to mount continuous attacks on distant objectives. Yet he noted without comment that current, and expected future, day bombers had a radius of action which was much lower than that which he saw as necessary for night bombers. This was certainly Air Staff practice at the time, and indeed remained so up to the time that the day/night distinction in bomber requirements ceased, as will be seen later in this chapter and in chapter 7.

This contradiction cannot be explained by a policy of waiting for the development of the desired dual-role bomber, for which no operational requirement was written. If in the absence of that type it was thought appropriate to specify a range for night bombers of 950 miles, why was a day bomber of that range not also specified? Economy is not an adequate explanation, because there were funds to develop several generations of long-range night bombers (Virginia, Hyderabad, Hinaidi, Heyford). It appears that, despite what was said about the relative vulnerability of night and day bombers, the Air Staff had little confidence in their key doctrine that bombers could defend themselves during deep penetration raids in daylight.

In chapter 2.3.2 it has been shown that from the first adoption of this doctrine there were doubts. Another example arose when Chamier suggested that heavy-gun fighters could be an effective counter to day bombers. Ludlow-Hewitt's somewhat lame response was that Chamier had overlooked that bombers could penetrate some forty miles into hostile air space before being intercepted. He added that if they were successfully attacked, then a two-seat fighter escort would have to be provided.[74] None of the required range existed or was contemplated at that time, or indeed in the future, although Ludlow-Hewitt

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[74] 5/1132, Commandant RAF Staff College to DCAS, March 1929

mentioned the possible use of the Hart bomber in this role.

Doubts about the viability of long-range day bomber operations were certainly justified by the experience of the 1914-18 War. Germany developed large multi-engined bombers so as to get the range to bomb London, and initially made daylight raids with these aircraft. Morris says that the later change to night bombing was attributed by German writers to improved defences.[75] When the Royal Flying Corps obtained multi-engined bombers in 1917 (again to get range) they used these at night.[76]

A bomber designed for long range was likely to be able to carry a relatively large bomb load. It was also likely to be relatively slow, and vulnerable to fighters in daytime. There thus developed the tradition that heavy bombers were night bombers, or *vice versa*, and it was only these which had a long range. Welsh took this attitude further in his outline requirements for a Giant night bomber. He coupled a bomb load of 4,000 lbs with a radius of action of 500 miles[77] - twice that of contemporary day bombers.

4.3 NEW FIGHTER CONCEPTS

By the end of the 1920s fighters from the 1914-18 War had disappeared from home defence fighter squadrons, having been replaced by Siskin IIIAs and Gamecocks. These types, and their planned replacement, the Bulldog, were nominally zone fighters for day and night operation. Like their predecessors, they were armed with two Vickers 0.303in machine guns, but had a higher performance than the types which they replaced. In 1927 the Air Ministry issued two specifications which broke new ground. These were F.10/27

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75 Morris, page 233

76 Jones, H.A., The War in the Air Vol VI, 1937 Operations of the Independent Force, pages 118-174

77 9/37 Folio 10, Appendix

for a multi-gun fighter and F.20/27 for an interception fighter. In 1929-30 the Air Staff re-opened consideration of a two-seat fighter. These three important developments are described below.

4.3.1 The Multi-Gun Fighter

The multi-gun fighter was the creation of the Directorate of Technical Development. It was argued that as bomber speeds increased, attacking fighters would have only a short time for aimed fire, and thus needed a high volume of fire to be effective. To meet this need, specification F.10/27 called for the installation of six machine guns.[78] In chapter 3.3.1 it is noted that the Air Staff opposed this project because they believed that its performance would be poor. The need for greater firepower was not questioned, but if a fighter could not get into position to use its guns it would be useless. The C.O.W gun fighter projects had the same problem.

Two prototype aircraft were built to specification F.10/27, one by Glosters[79] and one by Saunders Roe (with four guns)[80]. These aircraft were used in firing trials during 1930-32 which provided evidence of the need for increased firepower if a fighter was to be effective in fleeting encounters.[81]

4.3.2 The Interception Fighter

Specification F.20/27 was the first for an interception fighter, and was unusual in that the opening paragraphs on "General Requirements" defined the task of the aircraft,

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[78] 2/778, Multi-Gun Single Seater Fighter Specification No. F.10/27

[79] PRO: AIR 2/848, Gloster Multi-Gun Fighter Specn 10/27 - Type Requirements

[80] PRO: AIR 2/817, Saunders 4 Gun Single Seater Fighter - Specn. 10/27. Type Requirements

[81] PRO: AIR 2/625, Gun Armament in Aircraft (Policy), Trials Report, 27th November 1931

with industry invited to offer ideas for meeting that task. The main requirement was for "The capability of overtaking in the shortest possible time an enemy aircraft who is passing overhead at 20,000 ft. at a speed of 150 m.p.h.". An ability to climb to 20,000 feet in 12 minutes and a top speed of 190 mph at that altitude were suggested, but these aims were not to override the main requirement.[82]

It has been noted in chapter 3.3.1 that operational requirements for the interception fighter role had not been drawn up before 1927. Thus when Trenchard called for a specification, the DCAS (Air Commodore C.L.N. Newall) first reviewed the role of the class in the Home Defence Scheme, for the practice of equipping the interception squadrons with zone fighters had raised doubts about the interception fighter's correct function.

Newall began by noting that night bombers could be expected to fly low and slowly, and that zone fighters should be able to intercept them. He concluded that an interception fighter would be required only to operate against high-performance day bombers, and thus could be free of night flying limitations. Newall proposed that such fighters should be stationed on the South coast, and take-off only after warning of an attack was obtained from sound mirrors. They would then pursue hostile bombers on their way to bomb London. As there would be little time for interception, the fighters would need the highest performance and a high volume of fire, but little endurance and no radio.[83]

Sound mirrors were at best expected to detect aircraft at a range of 25 miles, and in practice achieved considerably

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[82] PRO: AIR 2/833, "Fury" S.S. Interception Fighter. Spec No. 20/27, 1A, Specification issued 17th August 1927

[83] PRO: AIR 20/168, Interception Fighters; Type Requirements and Trials, DCAS to CAS, 27.5.27. (drafted by Welsh, 20/168, F01 to DDOI, April 1927)

less,[84] so a nigh impossible system of interception was envisaged. This was found to be the case in the Air Exercises of later years.

Newall's proposals, which included an armament of four machine guns, were approved by Trenchard.[85] But after an administrative mix-up only two guns were called for when specification F.20/27 was issued in August 1927, although with the facility to change from 0.303in to 0.5in.[86] The inclusion of this facility is inexplicable, for a key requirement was a high volume of fire, i.e., "the greatest number of rounds in the shortest possible time", which was best obtained by a large number of small guns each with a high rate-of-fire. To this end a gun of even smaller bore than 0.303in was contemplated.[87]

The issue of armament for the interception fighter was re-opened in the following September. Welsh wrote to the DCAS to say he had seen a mock-up of the Bullpup, a private venture fighter design by Bristol, which had four 0.303in machine guns. Welsh said that the designer did not think that four guns would have affected the performance, except for the extra weight. Bristol were modifying the machine to meet specification F.20/27 with two guns, but Welsh suggested that the Air Ministry should call for two extra guns. Then if it was found on test that the performance was affected they could be removed.[88] Newall agreed, and in October 1927 he passed the papers on the Bullpup to the Director of Technical Development for his views.[89] Six months later the DTD minuted his reply to Newall, saying, "I think it is dead: it reached me on 12.4.28."[90]

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84 PRO: AIR 20/155, The Use of Sound Mirrors by RAF Personnel during the ADGB Exercises 1933
85 2/794, CAS to AMSR, 31.5.27
86 ibid., DCAS to AMSR, 2.8.27
87 9/37 Folio 10, page 9; see also PRO: AIR 41/82, Armament Vol.II, page 14
88 2/794, FO1 to DCAS, 29.9.27
89 ibid., DCAS to DTD, 3.10.27
90 ibid., DTD to DCAS, 12.4.28

Trenchard was incensed when he saw this minute. He wrote to the AMSR (the DTD's senior officer), to say that a request for remarks on the Bullpup had got an unintelligible reply five months later. He also pointed out that the contemporary C.O.W. gun fighter specification (F.29/27, chapter 4.2.2.2) asked for the same performance as the interception fighter with a gun load much heavier than that of the four 0.303in machine guns which the Air Staff had first proposed for the latter. Trenchard said that he had agreed to four guns for the interception fighter, subject to there being no significant loss of performance. It now appeared to him from the Bullpup story and from the C.O.W. gun fighter specification that a significant loss in performance was not expected, yet when issued the interception fighter specification called for only two guns.[91]

In reply to Trenchard's admonition, the AMSR explained that neither he nor his DTD had seen the proposal to alter specification F.20/27 back to four guns until it was too late to change it. It transpired that the Air Staff had borrowed the file containing the reference to the Bullpup and kept it for some months, during which time the DTD had issued the specification. In regard to comparison with the C.O.W. gun fighter, he explained that this specification was not the same as for F.20/27, and that allowance had been made for the higher military load of the former.[92] The DCAS (Newall) had taken up this apparent anomaly with the Director of Technical Development a few weeks earlier.[93]

Trenchard accepted these explanations (it seems it was he who had kept the file!), and agreed that as the specification had gone out to tender, and contractors were working on their designs, it would be wrong to change

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[91] ibid., CAS to AMSR, 1.5.28
[92] ibid., AMSR to CAS, 4.5.28
[93] 2/347, DCAS to DTD, 3.4.28

it.[94] This comment underlines the difference between an operational requirement and a specification.

The significance of this episode, coupled with the experiment with a six-gun fighter, is that as early as 1927 the three senior officers with the greatest influence on RAF aircraft procurement, Trenchard (CAS), Newall (DCAS) and Sir John Higgins (AMSR), were strongly in favour of increasing the fire power of RAF single-seat fighters. This was to culminate in the eight-gun fighters of 1934-35, of which more in chapters 5 and 6.

Another point of interest, in the context of the comments made in chapter 1.2 regarding the apparent failure of many writers on the development of RAF aircraft to seek out the relevant specifications, let alone the background to them,[95] is Trenchard's mistaken comparison of the C.O.W gun fighter (F.29/27) and interception fighter (F.20/27) specifications. Whilst it was true that the main "General Requirements" of the specifications were the same, many pages later in the documents the "Contract Performance" requirements differed considerably.[96,97]

There were a number of tenders to specification F.20/27, including two monoplanes and the two multi-gun fighter (F.10/27) prototypes, both reduced to two guns.[98] The competition was followed by a production order for the Hawker Hornet,[99] later renamed Fury.

At the same time that specifications for the multi-gun and interception fighters were being developed, the Air Ministry was evaluating the tenders to specification 9/26.

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[94] 2/794, CAS to AMSR, 9.5.28

[95] for example, Mason's <u>The British Fighter</u> gives a misleading description of the origin and requirements of F.20/27 in his section on the Bristol Bullpup, page 202.

[96] 2/347, Contract Performance section of Specification F.29/27, 1st March 192[8]

[97] 2/833, Contract Performance section of Specification F.20/27, 17th August 1927

[98] 9/37 Folio 18, Types of Aircraft at Present in the Service and Types under Construction, February 1930

[99] 2/794, CAS decision, 16.5.30

This was for a standard day and night (zone) fighter, and the competition was won by the Bristol Bulldog.[100] It was intended to replace the Siskin IIIA (developed from a 1922 design), and gave an increase in maximum speed from 144 mph to 173 mph.[101] The next advance in zone fighter development came with the initiation of a replacement for the Bulldog, which led to the well-known and much misrepresented specification F.7/30. This is discussed in chapter 5.

4.3.3 The Two-Seat Fighter

In the 1914-18 War the two-seat Bristol Fighter, with one fixed forward-firing machine gun and one rear gun, was found to be an effective and successful fighting aircraft. Morrow describes it as "indisputably the best two-seat fighter reconnaissance craft".[102] It continued in service for many years after the war in the RAF's home and overseas commands, primarily on Army Co-operation duties.[103]

The success of the Bristol Fighter may have been due more to its success as an aircraft, an achievement in its own right in those days, than to the merits of a two-seater. It suffered severe losses until fought as a single-seat fighter with the additional advantage of rear defence.[104] Nevertheless, experience with this aircraft seems to have led many in the RAF to believe that there were advantages in two-seat fighters - a report on fighter and bomber squadron affiliation exercises in 1929 said that "The two-seater Fighter finds more supporters each year".[105]

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[100] Thetford, page 133
[101] 2/2815, DCAS to CAS, 31.5.30
[102] Morrow, J.H. Jnr., The Great War in the Air, 1993, page 243
[103] Thetford, page 131
[104] Jones, H.A., The War in the Air Vol III, 1931, page 336
[105] 2/1238, 1A, Extract from 1929 Affiliation of Fighter and Bomber Squadrons, 20th December 1929

But the issue under discussion in the 1920s concerned fighters to attack formations of bombers, for which the fighter *versus* fighter combat experience of the 1914-18 War was not directly relevant.[106] As explained earlier in this chapter, Welsh's view in 1928 was that there was no case for continuing the development of the two-seat fighter class. A change of opinion was triggered by a comment in the report on the 1929 affiliation exercises mentioned above. This was that, "It is possible that every designer of a fast Day Bomber could provide its own antidote by an adaptation of his two seater Day Bomber to a two seater Fighter."

At the instigation of Welsh (FO1),[107] the Deputy Director of Operations and Intelligence, Group Captain C.L. Courtney, took up the "own antidote" suggestion and proposed the conversion of two or three Hart day bombers to two-seat fighters.[108] This experiment was agreed by the CAS (Sir John Salmond) in February 1930, although in his view a two-seater would always have an inferior climb and thus be late in intercepting attacking bombers.[109] Specification F.15/30 covering conversion of the Hart bomber into a two-seater fighter was issued in October 1930.[110]

The above description of the resurrection of the two-seat fighter concept by the RAF in 1929 and early 1930 provides a further example of the importance of seeking the earliest thoughts on the development of aircraft for the RAF. It contrasts with Mason's claim that "When Camm put forward a design proposal to adapt the Hart itself as a two-seat day-and-night fighter in mid-1930 ... retaining

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106 PRO: 16/305, Study of Air Fighting Tactics at Northolt, C-in-C ADGB to Air Ministry, 23rd April 1928
107 2/1238, FO1 to DDOI/DCAS, 7.2.30
108 ibid., DDOI to DCAS, 10.2.30
109 ibid., CAS to DCAS, 25.2.30
110 PRO: AIR 2/849, "Demon" Two seater Fighter Specn F.15/30 Type Requirements

the Hart's performance, it was quickly realised that all manner of side benefits, ... would accrue".[111]

Within the Air Ministry there was some discussion as to whether a requirement for day and night operation of the converted Harts would lead to an unacceptable loss of performance (the Hart was a day bomber). Calculations were made to investigate this issue, and these started from the premise that the Siskin IIIA day and night fighter appeared to be satisfactory in service with a landing speed of 62 mph, although 55 mph had been required in the past.[112] The performance of the Hart Fighter Variant when equipped for night flying was deemed acceptable with a landing speed of 62 mph, and it was agreed to proceed with experiments into day and night operations.[113] It will be seen in the following chapter that the acceptance of a landing speed of 62 mph for night operations was then introduced into the parallel Air Staff *versus* technical branches debate over zone fighter specification F.7/30, with important consequences for that project.

The Hart Fighter Variant experiment was initiated because the RAF's high-performance day bombers were faster than its zone fighters. Welsh saw the reason for this as being the insistence on the highest rate-of-climb for zone fighters. He believed that it was this which led to an inadequate speed margin over day bombers.[114] The Research and Development (Aircraft) branch claimed that this was not necessarily the case,[115] (in fact it is in general true that maximisation of rate-of-climb and of top speed are conflicting design aims). Both Welsh and RD(A) missed the point that day bombers were being compared with fighters which were condemned to an inadequate day performance

111 Mason, The British Fighter, page 234
112 2/1238, Liptrot to AD/RDA, 8.5.30
113 ibid., CAS to DCAS, 7.7.30
114 ibid., FO1 to DDOI/DCAS, 7.2.30
115 ibid., AD/RDA to DTD, 19.3.30

because they were required to have a night flying capability. In effect the Air Staff were calling for night fighters to combat day bombers. It will be seen in section 4.5 that the senior officers of the ADGB Command hammered home this point after the 1931 Air Exercises had exposed the inadequate performance of zone fighters.

By 1933 a full squadron of Demons (as the Hart Fighter Variant was named) was available for fighter and bomber affiliation exercises. It had been thought that by taking position in front of and below a formation of bombers the two-seat fighters' rear gunners could then fire from a blind spot of the bombers' defence. But the ADGB reported that "a very important fact had been disclosed. This is that the position in front and below the bombers is difficult to maintain if the bombers practice evasion."[116] Indeed, Brooke-Popham later commented that such tactics implied "that the enemy will be good enough to continue flying in a straight line".[117]

The lack of coordination in the formulation of operational requirements was even more evident from the ADGB Command's apparent ignorance that two-seat fighters had been re-introduced primarily to combat fast single-engined bombers. The Command claimed that attack from twin-engined bombers was that most to be expected, and that their front guns would provide a good defence against the tactics planned for the Demon. It concluded that a fighter with a front turret would be more useful. No doubt the Command was aware that such types were under consideration, and actively supported by the Chief of the Air Staff. These developments are discussed in chapter 6.

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116 ibid., Extract from ADGB Report on Affiliation exercises 1933.
117 16/305, 78A, Notes on Design and Tactics of A.D.G.B. Fighters, 23rd April 1934, para.16

4.4 BOMBER SPECIFICATIONS

The RAF ended the 1914-18 War with single-engined bombers such as the Airco DH9 and DH9A, which were mostly used by day, and a twin-engined heavy bomber (Handley Page 0/400), which was used by night. Development of these two classes continued through the 1920s.

4.4.1 Day Bombers

In section 4.2.1.1 it is explained how the day bomber class came to be split into high and medium performance classes. No replacement was sought for the twin-engined Sidestrand in the 1920s, but the development of a new high-performance day bomber was to have far-reaching consequences. Not only on bomber development, but also for fighters - its part in the re-introduction of two-seat fighters has been discussed above.

In April 1926 Trenchard sought to replace the Fairey Fox by an aircraft with a British engine. He wrote that,

> I consider that the specification should state that we merely want the same range and bomb load as the "Fox" and that it should not land any faster. All the other advantages derived from the engine will then go towards the performance of the machine. This is of the first importance. We can make bigger type machines afterwards.[118]

This instruction followed a note from the DCAS in which he put the case for having "one or two bombing squadrons in the H. D. force with exceptionally high performance", for which range, load and landing speed should to some extent be sacrificed. He suggested that, *inter alia,* "It is of considerable political value to possess the fastest

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118 PRO: AIR 2/757, High Performance Day Bomber with Falcon X Engine Fox Replacement Type Requirements Spec. 12/26, 43A, CAS to AMSR, 7.4.26

bombing machine in the world in a squadron or squadrons."[119]

The result of Trenchard's instruction was the Hawker Hart and Hind series, powered by the Rolls Royce Kestrel. These types came into service from 1930 onwards and equipped many more than one or two squadrons. What had begun as a special type of limited value formed a major part of the day bomber force, and for a time was seen as the main threat from potential enemies.

4.4.2 Night Bombers

Operational requirements for night bombers in the 1920s sought modest increases in speed and ceiling but little change in bomb load, range or armament. Specification B.19/27 (issued August 1927) led to the last biplane heavy bomber to enter RAF service.[120] It called for,

> View and steadiness for precision bombing at night
> Capacity for self-defence
> Easy maintenance.

The requirements included a still air range at 115 mph of 920 miles, maximum speed not less than 120 mph, 1,546 lbs of bombs and three Lewis guns plus ammunition.[121] Prototypes from Vickers, Handley Page and Fairey all crashed, which delayed Service evaluation, but eventually the biplane Handley Page Heyford was ordered. One squadron was equipped with the Fairey Hendon monoplane as an interim measure in 1936,[122] but by then B.19/27 had been overtaken by a new night bomber specification, B.3/34 (the Whitley), which is discussed in chapter 7.

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119 20/84, DCAS to CAS, 10.3.26

120 Thetford, page 308

121 PRO: AIR 2/821, Vickers Twin Engined Bomber. Spec 19/27 Type Requirement, Specification issued 17th August 1927

122 Thetford, page 271

An indication of the state of aircraft development in 1927 is provided by the AMSR's alternative to B.19/27. This aimed to obtain reliability by specifying three engines.[123] In an age when many twin-engined aircraft could not maintain height on one engine, a twin was inherently less reliable than a single-engined aircraft, being more likely to experience engine failure. Trenchard objected to this proposal because of the loss of ceiling which would result,[124] but a prototype was ordered. It did not complete its trials.[125]

4.4.3 Giant Bombers

No specification for a Giant Bomber was issued in the 1920s, but some proposals emerged from the aircraft industry. These were in response to an Air Ministry specification for a large troop transport, and a private venture "Battleplane" project from Vickers.

Specification C.16/28 was primarily for a transport as required by the Air Staff,[126] but Wing Commander A.C. Maund (who replaced Welsh as FO1 in September 1930) reported that, "The designers have, however, foreseen that the performance will be comparable with the night bomber class and have included the requirement for bombing without interfering with the other functions." Maund added that the Air Staff also thought that transports might serve as reserve night bombers.[127]

The two prototypes built to specification C.16/28 were heavy biplanes with a very large wing span - 115 feet for

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123 PRO: AIR 2/803, De Havilland "Canberra" Three Engined Night Bomber Spec No. 22/27 Type Requirements, AMSR to CAS, 2.12.27
124 ibid., CAS to AMSR, 9.12.27
125 Mason, The British Bomber, page 225
126 PRO: AIR 20/96, Bomber Transport Aircraft, CAS to AMSR, June 1928
127 9/37, Folio 18

the Handley Page.[128] When Maund saw one of them he reported that it would give problems with hangars, transport of spares and handling on the ground. He commented that, "As these machines are required exclusively for use abroad where facilities are limited, these difficulties become accentuated."[129] Both prototypes were abandoned. This experience was to lead the Air Staff to limit the span of future bombers.

An off-shoot of transport specification C.16/28 was a Vickers design for a "Battleplane". This project had an estimated military load (crew, bombs, armament) of 8,900 lbs, a top speed of 170 mph, and a range of 1,850 miles at 91 mph. Several possible uses were suggested by the company; as a "Battle Cruiser" to gain "temporary air superiority over a distant bombing objective", for long-range reconnaissance against opposition, and as a self-defending day bomber. As a night bomber it was claimed that the Battleplane would have a speed approximating to that of a night flying "scout", with the comment that scouts were unlikely to get faster because of their need for a low landing speed. Service as a troop carrier and transport was also suggested.[130]

The proposed aircraft was a large biplane with four engines in two tandem pairs, similar to the Handley Page V/1500 of 1918 in layout, armament, range and bomb load, but faster and with a higher ceiling.

The DCAS (Burnett) saw this proposition as an interesting night bomber but too slow for a day bomber. But after seeing a mock-up Maund was enthusiastic. He saw the Vickers machine as equivalent to six Harts, and with sufficient gun power to make fighter attack difficult. He

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[128] PRO: AIR 2/688, Interim Night Bomber (Requirements), Handley Page to Ludlow-Hewitt, 7th November 1933, Table 2B

[129] 20/96, F01 to AMSR, October 1931

[130] PRO: AIR 2/856, Vickers Four-engined Bomber (PV) Type Requirements, brochure dated January 1930

concluded that if the aircraft was successful there would be no need to divide home defence into day bombers and night bombers. Maund also agreed with Vickers that their Battleplane could be used as a heavy fighter. He suggested that "A squadron of such machines could interpose itself between enemy bombing formations and their objective"[131] - a reversion to the multi-seat fighter ideas of T.C.R. Higgins many years earlier. It will be seen in chapter 6 that at the time, early 1931, Maund was looking for a new type of fighter.

It is not known whether Vickers or Maund knew of Douhet's ideas, but the Vickers aircraft closely matched his specification for an all-purpose "battleplane".[132]

Vickers built and flew their Battleplane, but the technology on which it was based was out-of-date and they made a large financial loss.[133] Three months after the Vickers aircraft made its first flight in January 1931, the monoplane Boeing B-9 bomber first flew,[134] followed shortly by the similar Martin B-10.[135] In the next year Vickers themselves were designing a twin-engined bomber to specification B.9/32 (the Wellington, discussed in chapter 7) which bore little resemblance to the aircraft of the 1914-18 War.

Reference has been made to unsubstantiated claims in the literature that Air Staff bomber requirements impeded technical development by industry. But if the unconstrained efforts of industry could do no better in 1930 than to update the Handley Page V/1500, then the Air Ministry's record looks positively innovative. Similarly, Vickers' opinion that scouts were unlikely to get faster

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131 ibid., F01 to DCAS, 12.2.31
132 Douhet, pages 99-101
133 2/716, AMSR to DCAS, 22.8.34
134 Swanborough and Bowers, page 101
135 ibid, page 443

contrasts with the developments pursued by the Air Ministry which are discussed in the next chapter.

4.5 AIR EXERCISES: TESTING THE AIRCRAFT OF THE 1920s

To a certain degree the aircraft conceived in the 1920s were tested in Air Exercises, which the RAF first undertook on a large scale in 1927.[136] Other air forces did not undertake major exercises until 1931 when Italy, France and the United States held large scale air manoeuvres, although only those in France had objectives similar to those of the RAF.[137] The RAF's exercises in 1927, and those that followed in 1928, 1931 and 1932, employed many of the aircraft whose origin is described in this chapter. London was the target except in 1932.[138]

M. Smith and S. Robertson[139] maintain that these exercises were designed to test the basic theory of the counter offensive, and Smith remarkably suggests that they were biased in favour of the attack.[140] This was not so. The exercises were aimed primarily at testing the operational efficiency of units, and the detection, tracking and interception of raids.[141] The objectives set in 1927 specifically state that the purpose was not to investigate, "the relative effectiveness of offence and defence in air operations".[142]

The exercises were artificial in many respects. Bombers were required to radio their position and height, and this undermined an assessment of the interception system. The important finding of the effectiveness of the fast day

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136 9/69 Folio 41, ADGB Exercises - July 1927
137 Turner, G.C., "Air Exercises 1931, British and Foreign", JRUSI, Vol 76 (1931), page 731
138 Robertson, F.A. de V., "Air Exercises, 1932", JRUSI Vol 77 (1932), page 808
139 Robertson S., page 97
140 Smith M., page 72
141 Robertson, F., pages 809-810
142 9/69, Folio 41, para. 1(iv)

bomber (Fox) squadron in 1927 was said to be partly due to false reports of their height or to no reports at all. Similarly, the failure to intercept three out of twenty-five night raids was partly attributed to the bombers' failure to report their position.[143] In 1932, when searchlights were not used, the bombers were given set courses and were to use their navigation lights. (The report on the 1935 exercises said that this had been the practice in all years.[144]) The exercises were not wholly loaded against the attackers, for when the bombers "arrived over the target, the fighters were not allowed to worry them as they aimed their bombs."[145]

Given these conditions it is not surprising that what would later be thought of as a high level of success in interceptions was achieved, even at night.[146] Even so the Air Ministry was far from satisfied. In the December following the 1931 exercises the Air Council called for a thorough investigation into,

(a) The location and function of advance squadrons.
(b) Improvement of the system of warning and interception.
(c) Static defences.
(d) Improved aircraft types, and tactics.
(e) The distribution of guns and searchlights.[147]

Item (a) arose from the employment in 1931 of purpose-designed interception fighters for the first time, following the equipment of No. 43 Squadron with Hawker Furies (see section 4.3.2 above). The ADGB Command had reported that, "The most unsatisfactory feature of the exercises was the failure of interceptor [sic] squadrons to engage the bombers". In consequence it was proposed by AVM F.W. Bowhill, AOC Fighting Area (the fighter squadrons

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143 ibid. Folio 41,

144 PRO: AIR 20/184, Air Defence of Great Britain - Command Exercises, 1935. Report, sections 31, 109 and 117

145 Robertson, F., page 810

146 PRO: AIR 9/46, Air Gunnery and Fighting in the Air 1924-39, Item 4, Interception in Home Defence exercises, 1931-1933

147 2/1069, 40A, Air Exercises of 1931, Air Ministry to AOC-in-C, 30th December 1931

of the ADGB), and agreed by the Air Ministry, that for the 1932 exercises the interception squadrons should be re-positioned further inland and fitted with radio.[148] They were moved to the Aircraft Fighting Zone (not the "anti-aircraft zone" as stated by Bowyer[149]), for use as day zone fighters, in which role they were more successful.[150]

Item (d) of the Air Council's investigation arose from reports of the inadequate speed of zone fighters when faced with fast day bombers, and brought to the forefront the fundamental issue of the viability of one fighter type for day and night operation. Both the AOC-in-C of the ADGB (Ellington) and the AOC Fighting Area (Bowhill) suggested that the need for a faster day fighter meant that the policy of seeking fighters with a day and night fighting capability should be reconsidered. They also commented on the poor view from the single-seat fighters used in the exercises - Siskins, Bulldogs and Furies.[151]

In reply, the Air Ministry argued that it was likely that an enemy would seek a decision in the first few days of a war. Therefore a rigid distinction between day and night fighters would place the RAF at a serious disadvantage if it could only use 50% of its defence against an enemy concentration by day or by night. They accepted that some distinction might be inevitable, but hoped that it would be possible to restrict this sufficiently to enable concentration of both types by day in an emergency.[152] As regards the view from fighters, the Ministry said that efforts were being made to produce an improvement.[153] This will have been a reference to the importance attached to "fighting view" in the then recently issued specification F.7/30 for a Bulldog replacement. In the following chapters it will be seen how the lessons learnt from the

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148 ibid., 39A, ADGB Report, section 8, and Air Ministry to AOC-in-C

149 Bowyer, Interceptor Fighters, page 20

150 9/69, Folio 77, Comments of FO1 on Air Exercises, 1932

151 2/1069, 39B, ADGB Report, section 9 and section on Fighter Design and Tactics

152 ibid., Air Ministry to AOC-in-C

153 ibid, 39D, Extract from ADGB Report and letter to AOCinC ADGB from the Air Ministry

Air exercises influenced the next stages of development of fighter requirements.

The Air Council's investigation in 1931 was into aspects of the ground and air defensive system - but there was also some concern with the poor performance of bomber formations in finding and hitting their objectives.[154] This does not appear to have weakened confidence in the counter-offensive strategy.

4.6 THE 1920s IN RETROSPECT

In reviewing the development of the RAF's fighters and bombers in the 1920s, one is struck by the failure to compare the armament of one with the other. When T.C.R. Higgins in 1923 and Chamier in 1928 attempted a reasoned analysis of the problem of attacking hostile bomber formations, both concluded that a "big gun" fighter was the answer. Following Higgins' paper there was considerable investment in prototype aircraft to experiment with the large C.O.W. gun, but this was not matched by a re-appraisal of bomber requirements should the heavy gun fighter prove to be successful. Similarly, when steps which were taken in 1927 towards the doubling, even tripling, of the number of machine guns carried by a fighter, it was not deduced that the RAF's bombers would need to be more heavily armed. Chamier seems to have been alone in developing a theory of fighter defence and then deducing from it the response in bomber design which would be needed.

Whilst a major source of the grave doubts which existed about the feasibility of defending London against air attack was the apparent hopelessness of obtaining adequate warning, there was, and would continue to be, concern about the ability to mount successful attacks on hostile

[154] ibid, 39E, Air Ministry reply to section 22 of ADGB Report

bomber formations if interception was achieved. This concern was not based upon evidence from the 1914-18 War nor from trials or exercises. It followed from the creed of bomber invulnerability which led to an air defence policy based upon a counter-offensive.

The real problem was surely not whether all attacks could be prevented from reaching London, but whether sufficient losses could be inflicted on an attacking air force, before and after bombing, to diminish or deter further attacks before unacceptable damage was caused. Yet the studies made in 1924, 1925 and 1927 of the potential scale of a French air attack on London appear to have taken little account of attrition of the attacking air force by the defence. The scale of attack estimates took the form of a bomb tonnage to be expected for the first and second twenty-four hours and a constant rate thereafter.[155,156,157] It was said that reduction in this long-term rate was entirely dependent upon the scale of the RAF's counter-bombing offensive, which would take a month to have an effect. Certainly the RAF's fighter strength was weak in 1924, but less so in 1927, and strong enough in 1931 to have been adjudged to account for 75% of the attacking force in the three days of that year's exercises.[158] Yet the advice that a constant daily scale of attack was to be expected was continued in 1934, when Germany was recognised as the potential enemy.[159] In the 1936 assessment of potential German attacks on London referred to in chapter 2, it was repeated that the counter offensive was the one active means of reducing the scale of attack.

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155 9/69 Folio 24, Air Staff Notes on Enemy Air Attacks on Defended zones in Great Britain, 28.5.24

156 9/69 Folio 37, Scale of French Air Attack against Great Britain, 20th November 1925

157 9/69 Folio 42, letter to Wing Commander Sir Norman Leslie, CID, 17th October 1927

158 Turner

159 9/69 Folio 94, Estimated Scale of Possible Air Attack on London, prepared for 56th Meeting of ARP Committee, 1934

To summarize this chapter, although the 1920s were a period of financial stringency and the RAF grew little in size after the first impetus provided by the fifty-two squadron Home Defence Scheme, it did improve considerably the quality of its aircraft. Fighter development kept in advance of any elsewhere in the world, as did the new class of high-performance day bombers. But the Air Staff failed to see that its strategy of continuous, day and night, bombing was not matched by the aircraft it sought - a major omission in the analysis of operational requirements. It appears to have been seduced by the "high performance" day bomber, not only as a useful (and cheap) weapon in itself, but also as the likely form of attack on London, against which there was thought to be little defence. The RAF gave much credence to the untried doctrine of self-defending bomber formations, and thus undervalued its own progress in fighter development; so much so that consideration was given to an aircraft designed to ram a bomber, with the pilot escaping by parachute.[160]

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160 20/68, Conference to decide New Programme for Experimental Aircraft for 1927, 7th October 1926

5. THE QUEST FOR SPEED: from Bulldog to Spitfire

5.1 INTRODUCTION

The period 1930-1936 was one of great advances in aircraft design set against a background of dramatic changes in the international situation and the prospect of war. It began with France as the theoretical enemy and Paris as the planning target and ended with Germany as a real threat and Berlin as the target. These events had little impact on the assessment of desirable characteristics of fighters - apart from a continuation of the search for improved performance and fire power. Attacks on London were expected to be made by unescorted formations of bombers, particularly in view its distance from German airfields. To combat them the standard requirement continued to be for single-seat fighters with a day and night operational capability, but doubts about their effectiveness persisted.

These doubts arose from the belief that to obtain sufficient concentration of fire in an attack on a bomber formation, fighters must themselves attack in formation. But it was thought that, "A pilot cannot aim a gun and at the same time accurately maintain his position in formation".[1] In consequence much effort was put into the search for a fighter type and/or tactics which would allow the firepower of a formation to be concentrated. Little attention has been paid to these developments. They are discussed in the next chapter as part of an overall review of the search for increased firepower. This chapter describes the evolution of the Air Staff's performance requirements for single-seat fighters in the years 1930 to 1935. It shows how maximum speed came to dominate

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[1] PRO: AIR 2/1323, Novel Experimental Fighters, AOC-in-C ADGB to Secretary, Air Ministry, "Design of Home Defence Fighter", 24th January 1933, section 4

operational requirements at the expense of rate-of-climb, manoeuvrability, and particularly of endurance.

It will be seen that the Air Ministry responded to advances in engine and aircraft design in the setting of its operational requirements. Through these, and by encouraging and funding the aircraft manufacturing industry, the maximum speed expected rose from 180 mph in 1930 to 330 mph in 1935. The starting point of this spectacular advance was the drafting of specification F.7/30 for a day and night zone fighter to replace the Bulldog. This has been said to be "the most important fighter requirement ever".[2] It was indeed a landmark in the Air Staff's influence on fighter development, but it will be shown that the conventional wisdom regarding F.7/30 is based upon retrospective and often false interpretations.

The chapter continues with the plans to replace the Fury interception fighter, and the consequent decision to develop a fast day fighter despite the failure of the interception concept. This led to the first eight-gun fighter requirement, F.5/34. It was followed in 1935 by an Air Staff Requirement for an eight-gun day and night zone fighter, F.10/35, also with maximum speed as the prime requirement.

Designs to specification F.5/34 were not ordered into production, and Air Staff Requirement F.10/35 was not followed by the issue of a specification. It was met through the development of designs funded as part of the Air Ministry's experimental high-speed aircraft research programme. The way in which these events led to the Hurricane and Spitfire has been much misrepresented. Sections 5.4 and 5.5 trace the Air Ministry's intentions and decisions with careful attention to the sequence of events.

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[2] Bowyer, Interceptor Fighters, page 13

5.2 BULLDOG REPLACEMENT: F.7/30

In his catalogue of British fighters, Mason correctly refers to F.7/30 as an attempt to break the shackles of the biplane formula,[3] but claims that the requirement sought 250 mph at 15,000ft.[4] In his earlier survey of British fighters, Lewis also gave 250 mph, but said that "Both Vickers and Supermarine, with their F.7/30 tenders, broke away from the biplane in spite of the diehard official preference for it."[5]

The literature abounds with similar misrepresentations of F.7/30. In describing Supermarine's contender in the F.7/30 competition, Andrews and Morgan[6] correctly quote the maximum speed and the need for "an excellent all-round view", but wrongly state that the specification sought exceptional manoeuvrability and a steep climb for night interception. Barnes[7] and Jackson[8] say that F.7/30 called for a higher endurance/range than any contemporary fighter. Jackson and James[9] say a speed of 250 mph was sought, as do Stewart[10] and Brew[11]. The British Aircraft Specifications File 1920-49 ignores the actual specification entirely - it gives maximum speed 250 mph, landing speed 50 mph, range superior to any existing fighter, and a steep climb for night interception.[12]

In fact specification F.7/30 as issued in October 1931 called for a maximum speed of not less than 195 mph, and at no time in its evolution was a speed higher than 215 mph considered. Landing speed was to be not higher than 60 mph, and the specified endurance was the same as that

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[3] Mason, British Fighter, page 249
[4] Mason ibid., page 240
[5] Lewis, P., The British Fighter Since since 1912, 4th edition 1979, page 226
[6] Andrews, C.F. and Morgan, E.B., Supermarine Aircraft since 1914, 1981, page 204
[7] Barnes C.H., Bristol Aircraft since 1910, 1964, 3rd edition 1988, page 243
[8] Jackson, A.J., Blackburn Aircraft since 1909, 1968, page 309
[9] James, D.N., Gloster Aircraft since 1917, 1987, page 171
[10] Stewart, A., Hurricane, 1982, page 14
[11] Brew, A., Boulton & Paul Aircraft since 1915, 1993, page 321
[12] Meekoms & Morgan, page 147

sought by the RAF for earlier fighters of the same type (later increased only following the redefinition of endurance noted in chapter 3.4.5). A high rate-of-climb for day interception was a standard requirement for a zone fighter, and manoeuvrability was put fourth in order of priority as opposed to first for the Bulldog - which F.7/30 was to replace. (The RAF's waning concern with the manoeuvrability of fighters is noted in chapter 4.2.2.2.) Nevertheless, it was indeed the Air Staff's intention to encourage the development of a new configuration for single-seat fighters, and in this they succeeded.

Specification F.7/30 began life in October 1929 as part of the planning of new aircraft to be started in 1930-31. The key element in the Air Staff's thinking was to improve "fighting view", and Wing Commander Welsh (FO1) proposed a fighter with a pusher view[13] (i.e., avoiding the obstruction to view from the cockpit of the upper wing of a tractor biplane). In February 1930 it was agreed that to meet this view requirement, "a new specification is to be prepared for a single engine low wing monoplane with Halford engine. Zone fighter".[14] A draft specification (F.7/30) for this "Bulldog replacement" was produced by the Director of Technical Development (Air Commodore J.V. Holt) and sent to the DCAS (Newall) on 28th April 1930.[15] It initiated an eighteen-month debate which ranged over the performance, armament, configuration and engine requirements of RAF fighters.

In forwarding the draft specification to the CAS (Sir John Salmond), Newall explained that he had agreed with the DTD that "we would try to improve the view for fighting by definitely specifying a low winged monoplane".[16] This

[13] 20/68, Aircraft Development Programme: Notes on Conferences (from 1925), page 116, Wing Commander [Welsh, FO1] to DCAS, Remarks on Experimental Aircraft Programme for next year, 11.10.29

[14] ibid., page 70, Minutes of meeting ..... to discuss new experimental types for year 1930/31

[15] 2/2815, DTD to DCAS, 28.4.30; the draft specification is 1A, undated

[16] ibid., DCAS to CAS, 31.5.30

firm intention was to be weakened - not by "diehard senior officers" - but by the Deputy Director of Technical Development, Group Captain N.J. Gill. Although he saw no objection to stating that a low wing monoplane was acceptable, he feared that to definitely specify one might lead to an abortive tender competition in view of the failure of previous attempts.[17] This advice was questioned by Maund in February 1931,[18] but was reaffirmed.[19] In fact, as will be seen, a strong indication that a low wing monoplane was preferred was to be given in the specification when issued.

In his minute to the CAS, Newall also stressed the need for increased firepower - which he said they had been seeking for a long time. As regards performance, he expressed great dissatisfaction with the proposed maximum speed. Newall sought a speed of 215 mph as a reasonable increase over that of the Bulldog which the F.7/30 project was to replace, and this was agreed by the CAS.[20] However, performance assessments showed that no higher than 180 mph was compatible with a landing speed of 55 mph - seen as the maximum for operations at night - unless flaps and slots were used.[21] The Air Ministry did not exclude designers from using such devices, but it believed, correctly, that in 1930 they were not ready to do so. This question of an acceptable compromise between maximum speed and landing speed was to delay issue of F.7/30 for many months

Newall offered a landing speed of 62 mph (found to be acceptable with the Siskin, chapter 4.3.2), and the performance estimates were revised to give a maximum speed of 190 mph,[22] but this was unacceptable to Newall - he set

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[17] ibid., DDTD to DCAS, 16.7.30
[18] ibid., FO1 to DDTD, 11.2.31
[19] ibid., DDTD to FO1, 14.3.31
[20] ibid., CAS to DCAS and AMSR, 21.6.30
[21] ibid., RDA3 to DTD, 12.8.30
[22] ibid., DDTD to DCAS, 29.8.1930

200 mph as the minimum which would make the project worthwhile.[23]

The impasse began to be broken on 10th September 1930, after Sir John Higgins had been replaced as Air Member for Supply and Research by Air Vice Marshal H.C.C. Dowding. Dowding told his staff that "I should like to go a little slow in the issue of the specification for a new Bulldog replacement if there is no strong objection."[24]

The DTD (Holt) was clearly taken aback by this proposal to delay F.7/30. Money had been set aside in the Estimates for a new single-seat day and night fighter, and Holt feared that if it was not spent, then in the financial climate of 1930 it would disappear. He was also concerned with the availability of work for aircraft firms' design offices - some were getting short of work for the coming winter. These considerations illustrate the way in which financial stringency, and the RAF's perceived need to keep a national aircraft design and manufacturing capability in being, could influence views on acceptable performance characteristics. Holt advised Dowding that despite the Air Staff's concerns he was confident that the current proposal would produce a machine which would be superior to the Bulldog, and suitable for night flying. He added that the two-seater (the Hart Fighter Variant) had not flown at night and doubted that it would be suitable for night work.[25]

A year had elapsed since the first proposal for a Bulldog replacement, and the matter was reviewed at a meeting on the Experimental Aircraft Programme for 1931-32, held in October 1930.[26] Following this meeting Newall wrote to the CAS to review the whole position as regards the new

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[23] ibid., DCAS to DTD, 3.9.30
[24] ibid., AMSR to DTD, 10.9.30
[25] ibid., DTD to AMSR, 19.9.30
[26] 20/68, page 67, FO1 to DCAS, 7.10.30

fighter.[27] He dismissed the RAF's current zone fighters, Siskin IIIs and Bulldogs, because they were unable to overtake contemporary day bombers and had inadequate firepower and view. He reported that the meeting had agreed to the Air Staff's current requirement for a maximum speed of 200 mph and a landing speed of 60 mph, but that Dowding would not guarantee that the maximum speed would be achieved.

Newall then put his opinion to the CAS. He referred to pending trials of the two-seat fighter, to technical research on ancillary equipment which offered drag and weight savings, and to uncertainty in the use of the Bulldog at night. He proposed that unless the minimum performance requirements which had arisen from the meeting could be guaranteed, the F.7/30 project should be postponed and that research aimed at meeting the requirements should be pursued urgently. He concluded by referring to reports he had seen in the U.S. Air Services Magazine of two types of aircraft with retractable undercarriages, NACA cowlings[28] and metal airscrews. These would most likely have been the Boeing and Martin bombers mentioned in chapter 3.4.4.

Dowding independently raised other technical developments which he thought might justify a change of policy or delay for the Bulldog replacement. He drew attention to trials data for the Gloster multi-gun fighter (see chapter 4.3.1) with the comment "They are remarkable", and to reports from Bristols that they expected over 200 mph from a new fighter.[29,30]

The status of draft specification F.7/30 was then settled for the time being by Salmond. He told Dowding and Newall

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27 2/2815, DCAS to CAS, 10.11.30

28 developed from the British-invented Townend Ring - a cowling for air-cooled radial engines to improve cooling and reduce drag

29 2/2815, AMSR to DCAS, 12.11.30

30 ibid., AMSR to DCAS, 15.11.30

that it should be postponed for six months, and demanded vigorous action on the research issues that had been raised. As regards the references to the Gloster and Bristol fighters, he emphasised that the Bulldog replacement must be designed and equipped for night flying and have the necessary endurance as well as performance,[31] but he asked for reasons why the Gloster multi-gun fighter had not been accepted. Wing Commander Maund (FO1) explained that it had never been an Air Staff requirement, but had been concocted in 1927 by the AMSR (then Sir John Higgins) as an interception fighter, i.e., without the endurance and night flying capability of a zone fighter.[32] Ironically, the Gloster (SS19) Multi-Gun led via the Gauntlet to the Gladiator,[33] the aircraft which received the production contract envisaged as following from specification F.7/30.

The research which Salmond demanded was into improvements to the equipment carried by RAF aircraft with a view to achieving savings in drag and weight.[34] Maund had raised this issue in comments on the Experimental Aircraft Programme for 1931-32, where he noted that there had little progress since the 1914-18 war in the equipment carried in RAF aircraft. He said that the benefits of streamlined aircraft design were lost, because,

> When a Service aircraft takes the air with its full equipment on board, it looks like a neglected bramble hedge owing to the vast number of excrescences in the form of Service equipment.[35]

The decision to postpone F.7/30 and to concentrate on equipment research was communicated within the technical branches of the Air Ministry, and it was indicated that

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[31] ibid., CAS to AMSR through DCAS, 21.11.30

[32] 2/778, FO1 to CAS, 27.2.31

[33] Thetford, pages 284-286

[34] PRO: AIR 2/615, Policy Re Internally Stowed Engine Driven Aircraft Electrical and Wireless Generators to Replace Air Driven Generators, CAS to AMSR, 12.12.30

[35] 20/68, page 104, New Aircraft Programme 1931-32, Note by FO1, 6.10.30

the improvements sought would be forthcoming.[36] There is no reference to the suggestion made by Quill and Cox that the delay in the issue of F.7/30 was "almost certainly that the technical branches of the Air Ministry estimated that an engine of around 700 hp would be needed to meet the specification, and that in 1930 no suitable service engine of this power existed."[37] The question of engines for F.7/30 is discussed later in this section.

5.2.1 "Types of Aeroplane"

The six-months postponement ordered by Salmond ended in May 1931 and he duly asked Dowding if it was now possible to meet the "reduced" operational requirement. Salmond placed rate-of-climb as the first priority, a top speed of 200 mph second, good fighting view such as that given by a low-wing monoplane or pusher third, and manoeuvrability fourth.[38]

Dowding sought the advice of his Director of Technical Development (now Group Captain H.M. Cave-Browne-Cave), and was told that equipment development was proceeding satisfactorily, but that the best performance which could be offered was 195 mph (probably 190 mph in service), coupled with a landing speed of 60mph. In June 1931 a revised draft specification on these lines was sent to Air Commodore C.S. Burnett,[39] who had replaced Newall as Deputy Chief of the Air Staff.

Wing Commander Maund then drafted an important statement of the Air Staff's position and proposals to meet it.[40] With minor exceptions these were to be agreed by the DCAS and CAS. They were very different from those that have

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36 2/2815, DTD to AMSR, 15.12.31
37 Quill, J. with Cox, S., Birth of a Legend: The Spitfire, 1986, page 52
38 2/2815, CAS to AMSR, 18.5.31
39 ibid., AMSR to DCAS, 22.6.31
40 ibid., FO1 to CAS through DCAS, 29.6.31

been attributed to the Air Ministry by writers on the development of RAF aircraft in the 1930s. For example, in his The British Fighter Mason asserts in respect of F.7/30 that,

> No preference regarding the aircraft's configuration was expressed, so that manufacturers could submit either biplane or monoplane designs.
>
> By means of the latter omission, the Air Ministry intended to encourage industry to bear the burden of research into radical expedients, so long as the basic requirements were met.[41]

In the same author's Hawker Aircraft[42] he refers to "a deeply entrenched prejudice among some of the senior RAF staffs against the monoplane", and asserts that the Air Ministry was not inclined to encourage monoplane designs. He repeats that the stimulus to overcome this prejudice could only come from industry itself. Lewis's reference to "diehard official preference" for the biplane configuration has already been quoted. Divine says of the development of F.7/30 that,

> It epitomised once again the weakness of the administrative machine of the Air Ministry: its timidity in progress, the poverty of its imagination, the stultification of its bureaucracy.[43]

Maund's proposed policy was far from timid or lacking in imagination. He began by noting that the revised specification met the operational requirements except for ammunition supply and top speed. He explained that the deficiency in ammunition supply was relevant only to tractor biplanes, "which we want to see superseded"! Regarding the deficiency in top speed, he said that this was only 5 mph and argued that as there was to be a competition it could safely be assumed that if a firm could exceed 195 mph it would do so.

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[41] Mason, British Fighter, page 240

[42] Mason, F.K., Hawker Aircraft since 1920, 1991, page 35

[43] Divine, page 181

Maund next referred to a recent investigation into collisions (chapter 6.3.1), and referred to his paper, "A good fighting view", (it will be remembered that "fighting view" was the prime requirement which launched F.7/30). In this paper Maund concluded that the best view would be from a pusher, particularly if tailless and with the wings swept back, next best would be a low wing monoplane, with a tractor biplane as the worst.[44]

Under the heading "Types of Aeroplane", Maund continued his policy proposals by suggesting how the Air Ministry might get the aircraft manufacturing industry to develop new types of aircraft. He wrote,

> Past experience shows that, unless special action is taken, we shall inevitably be left to choose between certain tractor biplanes. This is because post war progress has become concentrated on "cleaning-up" the stereotyped form of aircraft, and firms have accumulated a great deal of knowledge of this type. They can forecast closely what they can do, and there is a minimum of unknowns to be faced. They regard tractor biplanes as 'bread and butter entries'; novel types as 'highly speculative'. The inherent shortcomings of the normal tractor biplane are becoming increasingly evident, particularly with fighters, and so real progress in the future will depend more and more on novel types; but there can be no chance of developing these unless experience is gained in adapting novel ideas to Service specifications, even if the Service cannot adopt first practical efforts in new directions.

Taking this analysis further, Maund put forward a list of firms that might be asked to submit tenders based upon the novel types of aircraft which they had been investigating. Should such types prove unsuccessful, he argued that as there had always been many private venture entries to official fighter specifications, there would be plenty of tractor biplanes to choose from.

Burnett (now Air Vice Marshal) agreed with Maund's analysis and proposals, with the caveat that he thought

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[44] 2/2815, 35A

that better results from novel designs would be obtained if the firms chosen to develop them were not also permitted to submit private ventures.[45]

Sir John Salmond firmly supported Maund's proposed policy. In a minute to Dowding in July 1931,[46] he first dealt with the ammunition issue by noting that it only applied to biplanes - "which I am anxious to see superseded". He observed that, "Cantilever monoplanes or pushers should find no difficulty in accommodating the required number of rounds". Then, taking note of Maund's paper on fighting view, he said the draft specification did not meet modern fighter requirements and wrote an amendment to the relevant section of the specification. The amendment defined what was meant by a "pusher view".[47] Otherwise Salmond approved the issue of specification F.7/30.

The Chief of the Air Staff then stressed the importance of encouraging novel types so as to get away from tractor biplanes. He agreed with Maund's assessment, commenting that "firms were reluctant to risk their money on highly speculative ventures of novel design". He told Dowding that,

> If we are to get serious attempts at novel types to meet this specification, we shall have to provide the incentive.
>
> Will you, therefore, ask firms who have been experimenting seriously with novel types to make special entries such as:-
>
> Tail-less type by Westlands.
> Monoplanes by Fairey, Gloster etc.,
> Pushers by Vickers,
>
> in addition to the auto-gyro, and assure these firms that this will not preclude them from entering 'private ventures' to normal design. You may have other novel types in view.

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[45] ibid., DCAS to CAS, 7.7.31

[46] ibid., CAS to AMSR, 13.7.31

[47] ibid., 35B

> In order to provide the necessary incentive I should like the designs, which you accept and pay for, concentrated among novel types as far as you consider them to be promising.

It is difficult to read into these instructions a lack of imagination, a preference for biplanes, or an unwillingness to fund radical designs.

5.2.2 Engine Policy

Dowding informed Burnett that the specification had been amended according to the CAS's wishes, and then said, "There is one further point, however, which is of great importance. I refer to the question of air-cooled versus water cooled engines."[48] It is surprising that this matter had not been discussed earlier, particularly as the technical branches' performance estimates must have been based on an assumed engine power, if not on a specific engine type.

The literature on this topic is adamant that the Air Ministry was wholly committed to the Rolls-Royce Goshawk (or Kestrel IV) evaporatively-cooled engine, then under development. Mason says that, "Implicit in the wording of the specification was the Air Ministry's preference for the Rolls-Royce Goshawk evaporatively-cooled in-line engine."[49] James says that the "specification also laid great stress on the use of the Rolls-Royce Goshawk".[50] Jackson[51] asserts that use of the evaporatively cooled Rolls-Royce Goshawk (or Kestrel IV) was specified, and Barnes that the "Air Staff indicated a preference for the evaporative-cooled Roll Royce Kestrel IV".[52] As will be shown, preference for the Goshawk in fact came from

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48 ibid., AMSR to DCAS, 5.9.31
49 Mason, British Fighter, pages 240
50 James, page 205
51 Jackson, Blackburn, page 309
52 Barnes, Bristol, page 243

industry. There was no mention of the Goshawk in specification F.7/30.

Dowding was Air Member for Supply as well as for Research, and he reviewed the current state of the British aero-engine industry as well as the merits of air or liquid cooling. He was concerned that the air-cooled engines under development at Napier and Bristol were in trouble, whereas Rolls-Royce liquid-cooled engine development was proceeding well. This, he said, "has introduced a marked tendency for aircraft firms to choose water or steam cooled engines in preference to air-cooled types". He noted that in consequence Napier were without orders for the next year and that Bristol were complaining of difficulties, as were Armstrong Siddeley. Dowding said that these firms were working on new air-cooled engines which, "if they prove to be successful, will be more valuable to us than steam or water cooled engines, owing to the absence of any vulnerable radiator surface". But if, he explained, the specification was to say that air-cooled engines were "<u>preferred</u>", then tenders which met the Air Ministry's preference would be at a disadvantage compared with those which ignored it, and installed liquid-cooled engines. Even so, such was Dowding's concern that air-cooled engine firms could go out of business, which he saw as a calamity if the need arose to expand production in the event of war, that he wrote, "From the supply point of view, my recommendation is that we should state unequivocally that an air-cooled engine is required, except in the case of 'pusher' designs".

Burnett put these views to Salmond, with the comment that survival of the manufacturers of air-cooled engines could be achieved by considering what other aircraft types might be specified to have them, but that,

> Unfortunately, the Zone Single-Seater Fighter is the one class in which, for operational reasons, we can least contemplate any sacrifice in attainable performance. Throughout the history of this class,

> there has never been produced a type which has given us adequate performance to meet the fastest contemporary Day Bombers.

Thus for F.7/30 he suggested that contractors should be left to choose either type of engine.[53] Salmond agreed with this policy. He said that, "For fighters we must take the engines whether water, steam or air cooled which give the best performance."[54]

Following this ruling and the CAS's earlier general approval, on the 30th September 1931 Dowding instructed his Department to amend and issue specification F.7/30.[55] As issued the first paragraph included the statement that, "A satisfactory fighting view is essential and designers should consider the advantages offered in this respect by low wing monoplane or pusher",[56] and later that "Any approved British engine may be used".[57]

5.2.3 The Outcome

The responses from aircraft manufacturing firms to the F.7/30 specification are interesting as a commentary on the two years of discussion of the requirements. All the fears which had been expressed within the Ministry came to pass to some degree. Westlands, who had been given an order for a Pterodactyl, gave higher priority to their private venture biplane entry.[58] Most of the invited tenders chose a Rolls-Royce liquid-cooled engine, for as Dowding anticipated, "The development of this engine gives designers using it a marked advantage in performance over the air cooled engine types". The Ministry accepted that

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53 2/2815, DCAS to CAS, September 1931

54 ibid., CAS to AMSR, 29.9.31

55 ibid., AMSR to DTD, 30.9.31

56 ibid., 44A, Specification No. F.7/30. Single Seater Day and Night fighter, 1st October 1931, section 1. General Requirements

57 ibid., 44A, section 2(a)

58 PRO: AIR 20/169, <u>Single Seater Fighters: Remarks on specifications</u>, RDA1 to AD/RDA, 13.11.32

it would have to rely on private ventures for air-cooled types.[59]

When forwarding these results to the DCAS, Maund noted "This specification brought out more originality and serious attempts to meet the operational requirement than any preceding specification."[60] Furthermore, Maund's hope that the encouragement of novel designs to meet RAF specifications - even if at first unsuccessful - would lead to improved fighters, was justified. For in section 5.4.3 it will be shown how the Supermarine low-wing monoplane response to F.7/30 led to the Spitfire.

It is relevant to this later development that in his review of tenders, Cave told Dowding that the designs to F.7/30 would probably be improved with an inverted engine which Rolls-Royce were developing.[61] In June 1932 Dowding informed Burnett that, "The design of the inverted Kestrel (to be called Merlin) is in hand and we shall place an order for 2 probably this year."[62] - which suggests that the Ministry planned some funding for the early development of the Merlin. (The intention to develop an inverted engine was not proceeded with.)

At the beginning of this section it is noted that many writers wrongly claim that the Air Ministry was seeking a speed of 250 mph when formulating F.7/30. It is always difficult to prove a negative, even though in the original sources on which this thesis is based no figure higher than 215 mph is mentioned, but a comment by Burnett on the performance estimates of the tenders to F.7/30 may be thought conclusive.[63] He pointed out that the Supermarine proposal did not meet the landing speed requirement, and that this might lead to it being unfit to fly at night,

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59 2/2815, DTD to AMSR, 30.5.32
60 20/169, FO1 to DCAS, 1.6.32
61 2/2815, DTD to AMSR, 30.5.32
62 ibid., AMSR to DCAS, 12.6.32
63 ibid., DCAS to CAS, 2.6.32

which he said was "an essential operational requirement". Burnett suggested that it would be wise to require an increase in wing area and accept some consequent loss in the estimated top speed of 244 mph, which he said it seemed could be afforded (and was done[64]). Burnett was unlikely to have taken this view if there had been earlier thoughts of seeking a maximum speed of 250 mph.

Burnett also mentioned that all the biplane entries had a configuration which gave a greatly improved view - which indicates that designers took heed of the carefully worded requirement for "a clear view upward and forward for formation work and manoeuvring".[65] Yet those writers who have noticed the emphasis on view claim it was for night flying.[66,67,68]

5.3 PRIORITY FOR SPEED

The previous section of this chapter has shown that in 1930-31 the Air Ministry sought to get industry to break away from biplane designs, but doubted that it could at the same time get a significant increase in fighter performance. In the next few years the pace of development of aeronautical engineering was such that much higher speeds became possible. The RAF feared that when these developments were applied to bombers the defence of London would become even more difficult. They therefore moved towards making maximum speed the prime operational requirement, first for day fighters, and then for the standard day and night zone fighter class. The best estimate of 195 mph for F.7/30 in 1931 was raised to 315 mph for its replacement four years later.

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[64] PRO: AIR 2/2741, Intercepter (sic) Fighter: Type Requirements & Specn. F.5/34, 5A, 27.2.33
[65] 2/2815, 44A, Section 7(b)
[66] Jackson, Blackburn, page 309
[67] James, page 204
[68] Mason, British Fighter, page 243

Hand-in-hand with the increase in engine power that contributed to this advance went an increase in engine weight, and thus in total aircraft weight. One consequence was that a military (pay)load which was the same percentage of all-up-weight as in earlier years could now include much heavier armament - a development long sought by the Air Ministry. These benefits were not obtained without some loss, most particularly in endurance, but also in manoeuvrability.

Two fighter requirements led this process. The interplay between these and the Ministry's high-speed aircraft development programme, an interplay which resulted in the Hawker Hurricane and Supermarine Spitfire, has led to much confusion in the literature. This confusion stems partly from a failure to grasp the RAF's fundamental distinction between the zone (day and night) and the interception (day only) classes of fighter, and partly from a failure to clarify the sequence of events.

Before discussion of these matters it will be helpful to summarise the four designations which arise frequently in the literature and in this chapter.

> <u>F.5/34</u> was for a day fighter, known as the Fury replacement.
> Operational requirements were agreed in August 1934 and a specification was issued in November 1934.
> Prototypes were ordered from Bristol and Gloster.
>
> <u>F.36/34</u> was a number assigned to a Hawker experimental fighter design.
> The decision to order this aircraft was made in September 1934. There was no specification.
>
> <u>F.37/34</u> was for a Supermarine experimental fighter design, first known as the 'modified' F.7/30.

> The decision to order this aircraft was also made in September 1934. A brief specification was issued in January 1935 - this was based upon specification F.7/30.
>
> F.10/35 was for a day and night fighter. Operational requirements were agreed in March 1935 and circulated to industry in April 1935. No specification was issued.

After requirement F.10/35 had been issued it was decided that the two experimental fighter designs, F.36/34 and F.37/34, could be developed to meet it, and these became the Hurricane and Spitfire respectively. It was also decided that the prototypes then being built to F.5/34 should also be modified to meet F.10/35, but there was no production order for these designs.

It is noted in chapter 1 that the Official History on Design and Development of Weapons was published before the relevant Air Ministry files were generally available. It must take some of the blame for leading later writers to confuse both the importance at the time of the different classes of fighter, and the sequence of events - not least because the Appendix written in 1945 by Air Marshal Sir Ralph Sorley, who was a major participant in the events discussed in this chapter, is incomplete and misleading - as is his article published in "The Times" in 1957; this is discussed in chapter 6. In terms of timing, Sorley's memory of these events is outdone by the comments of another Air Staff officer of the 1930s, Sir John Slessor. He wrote that, "it was not until 1932 that the Hurricane and Spitfire specifications were put out, and those of the Wellington and Hampden not till the following year."[69] In fact it was the latter which appeared in 1932, with the requirement which led to Hurricane and Spitfire appearing in 1935.

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[69] Slessor, J., The Central Blue, 1956, page 203

The Official History makes no mention of the background from the 1920s of two distinct lines of fighter development, zone and interception. It claims that the Hurricane and Spitfire can both be traced back to zone specification F.7/30 - and that Hawker were asked to tender to that specification,[70] which they were not.[71] Hawker did submit a private venture biplane to F.7/30, but as will be shown in section 5.4, the Hurricane evolved from the company's interest in a notional Fury (interception) fighter replacement in parallel with their funded work on the High-Speed Fury research aircraft. Postan says that, "In the summer of 1935 Mr. Camm's aircraft was sufficiently advanced, and sufficiently promising, to be considered for the Specification F.10/35 as an up-to-date replacement of the Fury."[72] But as noted above, it was F.5/34 which was the Fury day fighter replacement.

Wood and Dempster's description of the development of the Hurricane and Spitfire in their much acclaimed work on the Battle of Britain, The Narrow Margin,[73] confuses the classes of fighter in the opposite sense to Postan. They maintain that the four-gun 'modified' Supermarine F.7/30 "met Air Ministry specification F.5/34". Wood and Dempster similarly confuse the development of the Hawker Hurricane. They claim that specification F.36/34 was "written around" a Hawker design with eight machine guns.[74] Apart from the fact that no specification was written, the Hawker design to which only the number F.36/34 was assigned had provision for four machine guns.

Terraine says that the work of Camm (Hawker) and Mitchell (Supermarine), the Merlin engine and the Browning machine

70 Postan, page 88

71 2/2741, 43A, Invitation to tender, sent to Gloster, Bristol and Westland, 2nd January 1935

72 Postan, page 89

73 Wood, D., and Dempster, D., The Narrow Margin, 1961, Appendix 1

74 Wood and Dempster, ibid

gun, "bore fruit in Specification F.5/34 (later revised to F.36/34 and F.37/34)".[75] It will be shown that no such revision was contemplated or relevant.

Andrews and Morgan claim that in May 1935 "representatives of the Air Ministry operations branch" pressed Supermarine to fit eight guns to their F.37/34 as this armament had already been specified for F.5/34. They wrote that "This requirement was readily accepted by Mitchell on 29 April 1935, under enabling specification 10/35".[76] It will be shown that (at the time) Sorley clearly believed that consideration of eight guns for Supermarine's experimental aircraft F.37/34 followed Mitchell's receipt of Air Staff Requirement F.10/35. In no sense was this an "enabling" document for a design already in progress.

King, in referring to F.5/34, goes so far as to say that, "upon Mitchell's proposals, emphasising climb and manoeuvrability, the specification calling for eight guns was formally written."[77] Conversely, Mason claims that F.5/34 "was drawn up to cover the Hawker design proposal", and that "on 4th September [1934] the *full* Specification, F.36/34, was issued to Hawkers."[78] Bishop also gets the events of 1934-35 in the wrong order. He says that F.5/34 was issued early in 1935, and that Camm "was already confident of bettering it. The Air Ministry issued a revised Specification F36/34 in terms of what Hawkers were already doing."[79] In fact the decision to order the Hawker design was made in September 1934, and it bears repeating that there was no specification F.36/34 documentation. Bishop joins many others in claiming that the Hurricane, and the Spitfire, were private ventures, overlooking that the Air Ministry had decided to fund both prototypes as experimental high-speed aircraft before

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75 Terraine, page 18

76 Andrews and Morgan, Supermarine, page 213

77 King, H.F., Armament of British Aircraft 1909-1939, 1971, page 261

78 Mason, Hawker, page 37-38, italics added

79 Bishop, E., Hurricane, 1986, page 8

either specification F.5/34 or requirement F.10/35 were issued. Wykeham, who says that he had full access to Air Historical Branch papers, asserts that the F.5/34 specification, which he says was issued in January 1935, "fitted well with Hawker and Supermarine projects". He makes no mention of F.10/35.[80]

Let us return to the reality of Air Ministry thinking and actions during what turned out to be the critical years of 1932-35.

5.3.1 Fury Replacement: F.5/34

The estimated top speed of the Supermarine tender to the day and night fighter specification F.7/30 was much higher than that of the Fury day fighter then in service.[81] It was likely that an even better performance could be obtained if the night flying and other zone fighter requirements were dropped. In October 1932 Maund (FO1) examined this possibility on the instructions of the DCAS (Burnett).[82]

Maund estimated that without the requirement for night flying, and with endurance reduced to that of the Fury, a four-gun monoplane of design contemporary with the Supermarine F.7/30 would have a higher rate of climb and a maximum speed of 250 mph. (It may be this study which has led writers to believe that the Air Staff hoped for 250 mph from the original F.7/30 specification.)

Maund reminded Burnett that the DTD had recently said "definitely that it would always be possible to produce a specialised day bomber with a performance (meaning speed) equal to that of the best contemporary day and night zone fighter", and that a fighter with no margin of speed over

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80 Wykeham, P., Fighter Command, 1960, page 63
81 20/168, FO1 to DCAS, December 1932
82 20/167, FO1 to DCAS, 7.10.32

bombers was useless. He emphasised this point by noting that the maximum speed called for in the zone fighter specification F.7/30 issued in October 1931 was the same as that sought for the Hart day bomber replacement then under discussion in 1932 (chapter 7.2.2), whereas the ADGB Command had asked for a 50% speed margin.[83]

Maund was aware of the RAF's concern about the number of types in service (it had recently been criticised on this point by the Committee on National Expenditure[84]), but argued that the RAF "would be put in an impossible situation vis-a-vis the country in war if we were able to build machines fast enough to tackle day bombers and did not do so on the ground that by this omission we reduced the number of types."

In December 1932 the DCAS (Burnett) put proposals for a new day fighter to Sir John Salmond (CAS). He said that there was financial provision for a Fury replacement in 1933, and that, "It is suggested that the operational requirements should be based on substantially the same principles as those on which the successful Fury was evolved". Burnett took Maund's maximum speed estimate of 250 mph, but increased the armament to six machine guns, and, as with F.7/30, sought fields of view similar to those from a single-engined pusher. As this was to be a day fighter, he proposed a landing speed of 68 mph.[85]

Burnett had asked the AMSR's Department to provide an estimate of the best performance possible which met his requirements, and Maund explained that the Air Staff were simply seeking a view on the technical feasibility of a draft operational requirement. He asked if improvements in aerodynamic efficiency and engines might allow a maximum speed of more than 250 mph to be stipulated.[86]

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83 2/1323, 15A, AOC-in-C ADGB to Secretary, Air Ministry, 6th June 1932
84 PRO: AIR 9/8, Folio 41, Committee on National Expenditure 1931
85 2/2741, DCAS to CAS, 19.12.32
86 ibid., FO1 to DTD, minute 3 [December 1932]

This was surely a much better way of developing a feasible operational requirement than that which had been followed with F.7/30 and earlier, where the initiative had often been taken by the technical branches and then criticised by the Air Staff. As discussed in chapter 3.3.2, when Ludlow-Hewitt replaced Burnett as DCAS he formalised consultation at an early stage by setting up meetings of all those concerned with new operational requirements.

Both Maund and Burnett had put rate of climb as the first priority for the new fighter, but had also specified that it was to be based upon the same principles as the Fury. This contradiction was exposed when the DTD (Cave) asked if the climb required was to be at best climbing speed and not, as with the Fury, that to give the quickest interception of an enemy at a specified height and speed.[87] His staff were told that the climb requirement was for the best to 20,000 ft.[88] This apparently innocent detailed technical question and its answer exposed a lack of continuity of thought by the Air Staff, and brought home that it was implying a significant change of policy.

Maund and Burnett had overlooked that the Fury had been designed to meet the concept of an "Advance" or "Interception" fighter. This concept had been found to be unworkable in the Air Exercises of 1931. In consequence, as noted in chapter 4.5, the Fury squadrons were moved from their advanced bases back to the Aircraft Fighting Zone - to serve as day zone fighters. Zone fighters needed a high rate-of-climb to attain their patrol height quickly, a requirement which would lead to a different design optimisation from that to meet the interception concept, where speed and distance covered in a pursuit climb were important. This issue had arisen when the requirements for an interception fighter were first

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[87] ibid., DTD to AMSR, 23.12.32

[88] ibid., 5A, 27.2.33

considered in 1927.[89] Plans to simply replace the Fury after its operational role had been discredited required some explanation - even though as the fastest fighter then in RAF service the Fury was seen as a successful aircraft.

These matters were taken up by Wing Commander A.T. Williams in April 1933, after he had replaced Maund as head of Flying Operations 1. Williams was aware that the Fury had been introduced to test the Advanced scheme and had failed, and he questioned the need for a replacement of that type in addition to zone and two-seat fighters. He suggested that a new day fighter was worthwhile only if it had a rate-of-climb sufficiently higher than that of a day and night fighter. From a comparison of four, six and eight-gun Fury replacements with the Supermarine F.7/30, it was evident that this was not so. Williams concluded that the higher speed expected of a Fury replacement did not counterbalance having a third type of fighter, with low endurance, high landing speed, and restricted to day flying. As an alternative, he suggested fitting more guns in place of the night flying equipment of a zone fighter as a way of getting a day fighter without introducing a third type.[90]

This suggestion missed the point made earlier that it was the relatively poor top speed of aircraft designed for night landings that was the problem in combating fast bombers. After criticism of his proposal from the DDOI (Peirse)[91] and from the DCAS (now Air Vice Marshal E.R. Ludlow-Hewitt),[92] Williams came round to accept that a compromise day and night fighter "would be valueless for day fighting without the essential margin of performance and fire power". He also took up a point made by Peirse, (and earlier by Maund) that,

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89 20/168, FO1 to DCAS, 13.5.27
90 ibid., FO1 to DCAS, 4.4.33
91 ibid., DDOI to DCAS, 29.5.33
92 ibid., DCAS to FO1, 2.6.[33]

> It seems certain that political considerations will always force us (at any rate in war) to maintain in our defence a certain number of Fighter aircraft giving the highest possible margin of superiority over contemporary foreign Bomber aircraft.[93]

Ludlow-Hewitt then sought to persuade the CAS (now Air Chief Marshal Sir Edward Ellington) that the RAF should adopt "the policy of equipping a few squadrons with a fighter developed to produce as high a fighting performance as possible at the sacrifice of other characteristics such as endurance and landing speed." He admitted that the AOC-in-C of the ADGB (Air Marshal Sir Robert Brooke-Popham) was opposed to keeping three types of fighter in service, and that he wished development to be concentrated on the day and night fighter. But Ludlow-Hewitt told Ellington that,

> Nevertheless, we should probably make quicker progress in producing the best possible type of fighter if we continue practical research in the direction of combining maximum performance with an adequate measure of safety in landing and the other characteristics necessary to render the aircraft efficient as a fighter.

He pointed out that maximum performance would only be of use if the landing speed was reasonable, and view, endurance and other factors were acceptable, and that the more these characteristics were developed the more the aircraft would resemble a "day and night " fighter.[94] It will be shown later that this was good reasoning in the then climate of rapid improvements in aviation technology.

Ellington's response in July 1933 was not encouraging. He said that,

> If we had unlimited capacity for developing experimental machines and also unlimited money, there would be no doubt that we should go ahead with a maximum performance multi-gun single seater fighter.

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[93] 2/2741, 10A, Pro and Cons - for the retention of Specialist Day Fighter, June/July 1933

[94] ibid., DCAS to CAS, 11.7.33

But he pointed out that there were already a number of fighters under consideration, and that it was beyond the capacity of Dowding's technical staff to deal with them. He asked what priority was proposed by the Air Staff.[95]

Ellington was sceptical of the value of single-seat fighters because they were not able to fight in formation, a key feature of RAF fighter tactics. Moreover one of the fighters under consideration was Ellington's own project for a fighter specifically designed to fight in formation, as was the concurrent "Novel fighter". These are described in chapter 6.

Ludlow-Hewitt consulted Dowding about workload and priorities,[96] and after some discussion it was decided that Ellington's project and the Novel Fighter should go ahead in 1933, and that the Fury replacement should be delayed until the next year.[97,98,99] Its provisional 1933 designation F.16/33 was replaced by the better known F.5/34,[100] and the funds in the 1933 Estimates earmarked for a single-seat fighter were diverted to Ellington's project.[101]

In the spring of 1934 the Fury replacement project was resurrected and estimates of its performance were updated by Captain Liptrot to take account of contemporary engines.[102] These were the Fairey Prince, and later the Royce PV 12 (Merlin),[103] both liquid-cooled in-line engines. (Sorley was later to write that a "radial, air-cooled fighter" was envisaged for F.5/34,[104] but this is to

95 ibid., CAS to DCAS, 13.7.33
96 ibid., DCAS to AMSR, 16.8.33
97 ibid., DTD to DCAS, 22.8.33
98 ibid., DCAS to DTD, 23.8.33
99 ibid., DTD to DCAS, 28.8.33
100 20/68, page 124, Specifications for new type Service Landplanes (Excluding DTD types) 1928-
101 2/681, 16A, Tender Designs to Specification No. F.22/33, DTD to AMSR, 31.7.34
102 2/2741, FO1 to RDA3, 27.3.34, and 22A, RDA3 to OR, 23.5.34
103 ibid., 27A
104 Postan, page 539

confuse what happened with what was expected.) The performance estimates were based upon an endurance of 1.67 hours, equivalent to the 1¼ hours specified for the Fury after account was taken of the change of definition of fighter endurance introduced in 1932.[105]

Liptrot compared four, six and eight gun options with maximum speed as the first priority, and a four gun example with best climb to 20,000 feet as first priority. The recently formed Operational Requirements section then drew up draft "Air Staff Requirements for Fury Replacement Aircraft".[106] These were sent to Ludlow-Hewitt by Squadron Leader Sorley, *de facto* head of the section following the death of Wing Commander Williams in June 1934.

Sorley drew attention to Liptrot's figures which indicated a very small difference in maximum speed between the four, six and eight gun options, and a significant drop in speed if design was optimised for climb. His recommendation on choice of armament is discussed in chapter 6 - of greater significance was his advice that optimisation for speed rather than for climb should be adopted.[107] This represented a major departure from the long-standing policy that rate-of-climb was the prime requirement of a home defence single-seat fighter. Sorley also suggested that the loss of manoeuvrability which would accompany optimisation for speed was acceptable, because the principle of short decisive attacks from astern did not require high manoeuvrability. As discussed earlier in this chapter, a step in this direction had been taken in F.7/30, and it had been foreseen in the late 1920s (chapter 4.2.2.2).

More urgency was injected into these developments by reports from abroad. The DTD (Cave) told the Operational Requirements section that,

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105 20/168, FO1 to DCAS, December 1932

106 2/2741, 23A

107 ibid., OR to DCAS, 5.7.34

> We receive from A[ir].I[intelligence]. reports of high speeds claimed for fighters built abroad. As our new Fighter Specifications F.7/30, F.5/33 and F.22/33 all sacrifice performance for other operational requirements, the situation may arise shortly that our fastest fighter is very much slower than some foreign fighters.

He asked for higher priority for the F.5/34 specification.[108] Cave would have been well aware that F.7/30 sacrificed performance for a night flying capability, and that the tenders for the two multi-seat turret fighters then under development, F.5/33 (Novel) and F.22/33 (CAS), were indicating a relatively low performance.

A meeting of the kind later known as the Operational Requirements Committee was held on 9th August 1934 to discuss the draft requirements for the day fighter F.5/34.[109] This meeting agreed to sacrifice not only rate of climb and manoeuvrability for speed, but also endurance. Sorley had proposed an endurance of 1.75 hours (at maximum continuous rpm),[110] slightly more than that of the Fury. The committee reduced this to 1¼ hours on the understanding that this would give a maximum speed of 277 mph,[111] and patrol at 150 mph for 3¼ hours.[112]

When specification F.5/34 for a day fighter was issued in November 1934, it called for eight Browning machine guns and a maximum speed at 15,000 ft of not less than 275 mph.[113] Prototypes were ordered from Bristol in March 1935 and from Gloster in May 1935.[114]

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108 ibid., 22A, DTD to OR, 17.7.34

109 ibid., [60A], Extract from Minutes of Conference on Air Staff Requirements for Fury Replacement, 9th August 1934

110 ibid., OR to DCAS, 5.7.34

111 ibid., 27A

112 ibid., DCAS to CAS, 5.9.34

113 ibid., 40A, Specification No. F.5/34. Single-Seat Fighter, issued 16th November 1934

114 6/22, ACM 572, Progress on Experimental Aircraft, 30.4.35

5.3.2 The Specification that Never Was: F.10/35

In the autumn of 1934, although trials of the F.7/30 prototypes had yet to take place, the DDOI (Group Captain A.T. Harris) told the CAS that shortcomings in their design were already apparent. He said that they lacked retractable undercarriages, flaps and enclosed cockpits. He suggested that under the political conditions then existing the production of a new type in the zone fighter class at comparatively short intervals was justified.[115] The political conditions were of course the emergence of the threat of German air power. Harris' proposal was agreed by Ellington,[116] and the Experimental Aircraft Programme for 1935 included a new day and night fighter to replace F.7/30.[117]

The requirements for this project, numbered F.10/35, were considered by the 'Operational Requirements Committee' on 29th March 1935.[118] This meeting continued the policies which had been adopted for the day fighter F.5/34. It decided that speed and fire power were more important than rate-of-climb and manoeuvrability. Significantly, although F.10/35 was required to operate at night, landing speed was not discussed at all - a far cry from the troubles in defining specification F.7/30. But by 1935 the use of flaps to give an acceptable landing speed without unduly compromising maximum speed had become common practice.

An armament of six, preferably eight, fixed 0.303in machine guns was agreed after some consideration of guns of greater calibre, and of traversing guns. These matters are discussed in chapter 6.

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115 2/716, DDOI (for DCAS) to CAS, 12.10.[34], page 3, para.(b)

116 ibid., 1A, [15.10.34], Note to DCAS

117 ibid., 6B, Minutes of Conference on Experimental Aircraft Programme, 16th October 1934

118 PRO: AIR 2/2821, Whirlwind Single Engined, Single Seater Day and Night Fighter, Specn F/37/35 Type Requirements, 3A

The most important decision concerned endurance. A Table had been circulated which showed the estimated relationship between maximum speed and endurance.[119] Air Vice Marshal C.L. Courtney (DCAS from 26th January 1935) proposed that endurance should first be decided, as the Table showed that this would determine maximum speed. Wing Commander H.A. Whistler then gave the views of the Fighting Area of the ADGB Command. He asked for fuel for ½ hour at Ground Level (or at 15,000 ft, whichever gave the greater) at maximum continuous power to cover climb and fuel reserve, plus one hour at economic speed at 15,000 ft for patrol, plus ¼ hour at full power for pursuit and attack. This was agreed.

The concept of determining fuel capacity by reference to a hypothetical operational sortie was new. It was certainly an improvement over the previous practice of simply specifying a number of hours at maximum power. Whistler's detailed prescription was equivalent in fuel capacity to an endurance of one hour at maximum continuous power (plus ¼ hour reserve), and from the Table this was compatible with a top speed of 315 mph. (The Minutes of the meeting record 310 mph, but this was corrected by Courtney when reporting to Ellington.[120])

Air Staff Requirement F.10/35 was circulated to industry[121] and drafting of the specification was put in hand.[122] It was to be overtaken by the events described in the next section, and the specification was amended to incorporate cannon armament as discussed in chapter 6.

Cannon armament would be heavier than the machine guns called for in F.10/35. Even so, when putting a cannon fighter proposal to Ellington, Courtney noted that the new aerodromes being built for home defence had a clear run of

[119] 9/37, Folio 32, Oxland (OR) to DCAS, 23.3.35
[120] 2/2821, DCAS to CAS, 6.4.35
[121] ibid., 13A and 13B, 25th April 1935
[122] ibid., DTD to RDA3, 26.4.35

1,100 yards, and that this would permit an increase in wing loading and make a speed of 330 mph possible.[123]

So in the space of four years the planned maximum speed of RAF fighters had risen from 195 mph in the final form of F.7/30 to 330 mph. An important contribution to this great advance was the Air Ministry's high-speed aircraft research programme.

5.4 HIGH-SPEED AIRCRAFT RESEARCH

In parallel with the Air Staff's consideration of the operational requirements for a high performance day fighter (F.5/34) and for a new day and night fighter (F.10/35), the Directorate of Technical Development was pursuing a high-speed aircraft research programme. This was later described by Dowding (when Air Member for Research and Development in September 1935) as a follow-up to the RAF's support of the Schneider Trophy racing seaplanes. He wrote,

> [1.] Since the time when we won Schneider Trophy outright we have ceased to seek after extreme speeds involving very high landing speeds and vast landing areas, but it has been policy to have one or two machines under construction which will be considerably ahead of latest service types in performance.
>
> 2. Such machines were the High Speed Fury, High Speed Hawker and Supermarine Monoplane.[124]

This section first describes the progress of the AMSR's Department's research programme through its dealings with Hawker and Supermarine in 1934. It is then shown how the outcome came to fulfil the single-seat fighter requirements which had been under discussion from 1932 to 1935. As has been shown, this is a contentious issue, with many contradictory claims in the literature.

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123 ibid., DCAS to CAS, 11.11.35

124 6/43, EPM 29/35, Note by AMRD, item (b), 21.9.35

5.4.1 Hawker

From 1932 the Air Ministry had funded the development by Hawker of the experimental High-Speed Fury. This was a Fury biplane fighter fitted with a special Rolls-Royce Kestrel engine, and later with new wings and the Rolls-Royce Goshawk engine.[125] In the course of this work there had been discussions with the company on the Ministry's high-speed aircraft development aspirations. Stewart claims that in August 1933 Hawker's Chief Designer (Sidney Camm) and the DDTD (Buchanan) had agreed that a Hawker Fury Monoplane design "was accepted in principle".[126] Maybe so, but when early in 1934 the company sent proposals for a monoplane fighter to Buchanan he minuted the DTD that,

> The attached proposal has been received from Messrs. Hawkers and arises out of discussions we have had with Mr. Camm on high speed development.
>
> The proposal is a method of overcoming the limitation of the existing high speed Fury due to its biplane construction.
>
> The proposal is for a new type of interceptor fighter not for a true high speed monoplane. Messrs. Hawkers will not separate high speed development from military utility and the work on the Fury has suffered from this cause.
>
> In any case it is clear that ultra high speed development must be associated with a monoplane and the Supermarine F.7/30 if successful may offer an opportunity to proceed with the work.[127]

In passing these views to the AMSR (Dowding), the DTD (Cave), although less critical of Hawker's pursuit of military utility, proposed deferring action on their proposal until the current re-build of the High-Speed Fury

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[125] PRO: AIR 2/652, Special Engine Development for High-Speed Aircraft: Policy, 1932-1933

[126] Stewart, page 14

[127] PRO: AIR 2/605, Proposal for a High-Speed Monoplane by Hawker Aircraft Ltd., DDTD to DTD, 19.2.34

was completed.[128] Dowding agreed with this approach, with the comment that,

> It is of course possible that the D[ay] & N[ight] Fighter Replacement may be so good that the Air Staff may agree to waive the requirement of a special Interceptor class with all its attendant disadvantages.

He saw Hawker's point regarding military utility, but felt that "this rather handicaps us in carrying out an advanced research programme in land speed."[129]

The "D & N" fighter referred to by Dowding was the Supermarine contender for specification F.7/30, and presumably by "land speed" he meant in contrast to the seaplanes of the Schneider Trophy races.

When the time came to re-consider Hawker's proposal in May 1934, Dowding agreed to a further three months postponement in the expectation that the performance of the High-Speed Fury and of the Supermarine F.7/30 would soon be known.[130] However, trials of both were delayed by trouble with their Goshawk engine.[131,132]

It is shown below that in concurrent discussions with Supermarine over their F.7/30 project, the Director of Technical Development (Cave) had come to the very important opinion that Hawker's, as well as Supermarine's, current ideas should be dealt with as part of the high-speed research programme. Thus when on 4th September 1934 Hawker (perhaps having been told of Cave's views) submitted a new proposal for a four-gun monoplane fighter, and re-opened the question of an order, this was quickly dealt with.

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128 ibid., DTD to AMSR, 22.2.34
129 ibid., AMSR to DTD, 25.2.34
130 ibid., AMSR to DTD, 13.5.34
131 ibid., RDA3 to AD/RDA, 27.7.34
132 ibid., DTD to AMSR, 24.8.34

Hawker's Chief Designer explained that the company's earlier proposal had been designed to meet the specification of the Fury and to compare a biplane and monoplane at full scale. He said that Drawing Office work had continued, but with the Goshawk engine replaced by the Rolls-Royce PV 12, and that there had been close cooperation with the Royal Aircraft Establishment on wing design.[133] Camm said that a top speed "approaching 300 mph" was possible, but the Directorate thought this optimistic and estimated 285 mph, with an endurance of 1.5 hours at normal rpm.[134]

In forwarding Hawker's proposal to Cave, Buchanan noted that in discussions on the specification for a Fury replacement the fitting of eight guns was proposed, but that,

> In view of the importance of high speed development, I recommend the ordering of this aeroplane as part of this work, apart from the question of the Fury replacement.[135]

Cave drew this minute and Hawker's proposal to the attention of Dowding, and endorsed Buchanan's recommendation to buy the aircraft as part of "our High Speed development work".[136] Dowding agreed immediately.[137] The Ministry's Contract Department were told on 20th September 1934 that, "It is proposed to place an order for this aeroplane. Could you ascertain the price."[138] The aeroplane was ordered at a contract price of £8,000[139] and given the number F.36/34; no specification document was issued.[140,141]

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133 ibid., Camm to Buchanan with Hawker Drawing E.57540, 4th September 1934

134 ibid., RDA3 to Dr. Coates/DDTD, 8.9.34

135 ibid., DDTD to DTD, 10.9.34

136 ibid., DTD to AMSR, 13.9.34

137 ibid., AMSR "Agree", 14.9.34

138 ibid., DDTD to AD of C.A., 20.9.34

139 ibid., file note unsigned and undated

140 Air Ministry file on Specification No. 36/34 held by the Air Historical Branch, Ministry of Defence

These facts, which demonstrate an awareness of need and speed of decision-making by Dowding's department, contrast with M. Bowyer's claim that, "Following lengthy, complex discussions of fighter policy the Air Ministry on 21.2.35 ordered a Hawker prototype to Specification F.36/34."[142] It is true that contractual matters were not settled for some months, a common state of affairs then[143] and now, but Dowding's decision was made in September 1934, ten days after receipt of Camm's letter. No issues of fighter policy arose.

5.4.2 Supermarine

In section 5.2 it is noted that Supermarine were awarded a contract for a prototype to specification F.7/30. This aircraft was given the company Type No.224. Completion was much delayed, partly by difficulties with the evaporative cooling of the RR Goshawk engine - a problem which bedevilled some other contenders for F.7/30. Meanwhile the company discussed with the Air Ministry modifications to their Type 224 which were expected to improve its performance. In July 1934 they referred to these discussions and proposed that the modifications should be incorporated into their entry for the F.7/30 competition. The company quoted a price for the modifications and sought approval to proceed with them.[144]

The Ministry checked Supermarine's performance estimates and agreed that the modifications should give a speed at 15,000 ft of 265 mph as compared with an estimate for the

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141 PRO: AIR 2/2822, Type Requirements for Specn F.36/34. (Hawker), this file has only "Specification 15/36 Hawker "Hurricane". Development - Production", issued 20th July 1936

142 Bowyer, Aircraft for the Few, page 41

143 2/1668, DTD to AMSR, 15.1.35, para.10

144 PRO: AIR 2/2850, Single Seater Day and Night Fighter to Spec. No. F7/30 - Kestrel IV Engine Preliminary Consideration of Design; Supermarine Aviation Works, Supermarine to Secretary, Air Ministry, 27th July 1934

unmodified F.7/30 aircraft of 235 mph. The proposed changes involved a reduced wing area, a conventional low wing, trailing-edge flaps, retractable undercarriage, retractable tail-wheel, closed cockpit and a smaller tailplane.[145] These "modifications" transformed the Supermarine Type 224, with its odd-looking cranked wing, fixed spatted undercarriage and open cockpit to the more elegant Type 300.[146] Supermarine's quote of £7,000 for the modifications was to a design whose first cost had been £8,500.[147]

The Directorate of Technical Development's very reasonable reaction to this proposition was that to place a contract for such major modifications to Supermarine's F.7/30 contender would be unfair to other companies with entries to the competition.[148] The Director (Cave) then proposed to Dowding a way of overcoming this serious contractual obstacle. He suggested that the Supermarine proposal, and the "Interceptor Fighter" design from Hawker, should "be considered quite apart from the present F.7/30 competition as they would be too late for consideration with that type." Then, after mentioning again that discussions on the next single-engined fighter indicated that eight guns would be required, he wrote,

> I think it would be a wise precaution to order one of these modified F.7/30s from Supermarine if they will quote a reasonable price and delivery date. It will be a suitable type on which to overcome many of the problems we shall have later with the 8 gun interceptor e.g. the combination of steam cooling, retractable undercarriage and guns in the wings. It will also be a most interesting experiment with wing flaps on a high performance monoplane.[149]

Dowding immediately agreed to this proposal, although he commented that, "There is no reason why they [Supermarine]

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145 ibid., RDA3 to DDTD, 9.9.1934
146 Price, The Spitfire Story, page 16
147 2/2850, 1A, Requisition for Purchase, undated
148 ibid., AD/RDA to DDTD, 14.8.34
149 ibid., DTD to AMSR, 23.8.34

should not have included retractable undercarriage & flaps in their original design. (You may remember that I asked you about this at the time)".[150] It has been explained in section 5.2 that Supermarine's initial tender to F.7/30 had not met the landing speed requirement and that an increase in wing area was necessary. Flaps would have been a way of meeting the requirement without an increase in wing area and consequent reduction in top speed. "Variable camber or equivalent devices" were permitted in specification F.7/30.[151]

At Cave's request,[152] on 4th September 1934 the Director of Contracts asked Supermarine to quote the cost and delivery of a new aeroplane, "generally on the lines of your proposals on Drawing 30,000, Sheet 2.", i.e., the 'modified' F.7/30. He said that the new aircraft was not to be regarded as a replacement for the company's Type 224, which was to be completed for the F.7/30 trials.[153]

This letter was sent just over one month after Supermarine's request for funding of the modifications. Considering the rapidity of this response it is surprising that Price says that, "The Air Ministry was lukewarm towards the new proposal".[154] He says that after a board meeting on 6th November 1934, Vickers (Aviation) decided to fund Mitchell's design work. Scott agrees, and quotes Sir Robert McLean of Vickers as writing that he and Roll-Royce decided that they would finance the building of a "real killer fighter", and that he told the Air Ministry that "in no circumstances would any technical member of the Air Ministry be consulted or allowed to interfere with the designers".[155] The Director of Contracts' letter must have been a great comfort when these bold decisions were made! Moreover, a manuscript minute by Dowding dated two

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150 ibid., AMSR to DTD, 24.8.34

151 2/2815 ibid., 44A, Section 4

152 2/2850, DTD to DoC, 27.8.34

153 ibid., 50A, Director of Contracts to Supermarine, 4th September 1934

154 Price, The Spitfire Story, page 16

155 Scott, J.D., Vickers, A History, 1962, page 202

days after the Vickers board meeting speaks for itself. Dowding wrote,

> Spoken to Sir R. McLean.
> Do not press the Dagger engine on this new F.7/30 project.
> Let them use Goshawk or P.V. 12.
> Give them the I.T.P. as soon as possible.[156]

The Intention to Proceed was issued on 1st December 1934.[157] A few days later it was agreed between the Directorate of Technical development and Supermarine that the Goshawk engine (on which the modified F.7/30 was based) should be replaced by the Rolls-Royce P.V XII (Merlin).[158] Price explains how the consequent change in planform led to the familiar outline of the Spitfire.[159] A brief specification (F.37/34) for an "Experimental High Speed Single Seater Fighter" was issued. It retained most of the requirements of the F.7/30 day and night zone fighter, but permitted all four guns to be outboard of the propeller disc.[160]

Thus the AMSR's high-speed aircraft research programme led to orders being placed for two experimental aircraft, F.36/34 (Hawker) and F.37/34 (Supermarine). The Air Staff had not been directly involved. Indeed, Sorley wrote that he did not know of the existence of the projects until after orders had been placed.[161]

5.4.3 From High-Speed Research to the Spitfire and Hurricane

Supermarine were one of the firms which received Air Staff Requirement F.10/35 for a new day and night fighter.

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[156] 2/2850, 53a, Dowding to DDTD, 8.11.34
[157] ibid., DoC to Supermarine, 1st December 1934
[158] ibid., Supermarine's Draft Notes on Conference at the Air Ministry on 5th December 1934. Improved D.N. Fighter. Type 300
[159] Price, Spitfire, page 17
[160] 2/2850, Specification F.37/34_Experimental High Speed Single Seater Fighter, issued 3rd January 1935
[161] Haining, P., The Spitfire Log, 1985, page 25

Sorley of the Operational Requirements branch visited the company in late April 1935, and he told Courtney (DCAS) that,

> Mitchell received the Air Staff Requirements for the 10/35 while I was there and is naturally desirous of bringing the aircraft now building [the F.37/34 version of F.7/30] into line with this specification. He says he can include 4 additional guns without trouble or delay.

Sorley noted that Hawker had a similar aircraft under construction (the F.36/34), and suggested "that we should likewise relate the requirements of this one to the 10/35."[162]

Sorley's memory seems to have failed him when he wrote about these events ten or more years after they occurred. In the two cited post-war publications he makes no mention of F.10/35 - he relates everything to F.5/34.

That it was F.10/35 which was at issue in the spring of 1935 is confirmed by a minute to the Air Staff from Air Commodore R.H. Verney (who replaced Cave as DTD from 17th September 1935). Under the heading "Single Seater Day and Night Fighter Specification F.10/35". Verney wrote,

> In view of the probable decision (not yet notified to me) that F.36/34 Hawker, and F.37/34 Supermarine Fighters are to be converted to this Specification, by ordering new wings for the Hawker, and altering the Supermarine which is still in the design stage, it is a matter for careful consideration whether the issue of this Specification should still be made?

Verney's concern was that Air Staff Requirement F.10/35 had already been circulated to industry, and a follow-up specification was expected. He suggested that the options were:

> (a) To let F.10/35 continue.
> (b) To withdraw it for a time

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162 PRO: AIR 2/2824, "Spitfire" (Supermarine) Single Seater Day and Night Fighter - Type Requirements for Specn 37/34 and Trials, OR to DCAS, 1.5.35

(c) To recast it making demands for an even more advanced design.

Verney favoured the last option.[163] His view of a more advanced design is discussed in chapter 6.

On seeing Verney's minute, Dowding wrote to Courtney, "I agree that the fact that you have 'roped in' my 2 experimental fighter prototypes rather alters the situation".[164] He advised holding up the F.10/35 specification, as did Wing Commander R.F. Oxland, head of the Operational Requirements section since October 1934. An Operational Requirements branch note (drafted by Sorley[165]) confirmed that the Hawker and the Supermarine designs were being modified to meet F.10/35 "in all essentials".[166]

Thus Ludlow-Hewitt's hope that practical research into a pure high-performance fighter would lead to an operationally acceptable day and night fighter was realised. Paradoxically, rather than the high-performance day fighter being developed to meet the requirements of a day and night fighter, it was the drastic reduction in the endurance required of the new day and night fighter which made this possible.

5.5 SUMMARY: The Zone And Interception Classes Merge

Since 1923 the RAF had pursued the concept of two classes of single-seat fighter. The standard zone class was required to operate by day or night, and to have an endurance which permitted patrol until the route and height of an attack were fully identified. The interception class was at first to be optimised for a pursuit climb from airfields on the coast. When the

163 2/2821, DTD to OR and DCAS, 21.5.35

164 ibid., Dowding to DCAS, 23.5.35

165 20/167, Note by S/L (OR), 28.5.35;

166 2/2821, 18A, OR to DCAS, 28.5.35

pursuit climb role had been found unfeasible the class was retained as a high performance, low endurance, day only zone fighter. The characteristics of the two classes began to merge as the introduction of flaps broke the link between maximum speed and landing speed, and night flying and radio equipment reduced in weight. But the most important factor was the reduction in the endurance specified for day and night zone fighters.

In going from F.7/30 to its replacement F.10/35, the Air Staff had accepted the advice of the Fighting Area and reduced the required endurance (at maximum normal rpm) from 2½ hours[167] to one hour, and reserves from ½ to ¼ hour. This startling change underlay Sorley's proposal that the Supermarine F.37/34 experimental fighter could meet F.10/35. He noted that the latter required only two-thirds of the fuel load of the former as a result of a halving of the required endurance and reserves. This saving in fuel weight would more than offset that of four additional guns.[168] It also explains how Hawker's experimental fighter, which Camm had based upon the Fury low endurance concept, could be deemed to meet the zone fighter requirement F.10/35.

The merging of the two classes was completed when the Bristol and Gloster prototypes to the Fury replacement specification F.5/34 were brought into line with F.10/35. The first step concerned endurance. That specified for the zone fighter F.10/35 was actually less than that of F.5/34 - one hour as compared with 1¼ hours. The Air Staff proposed to reduce F.5/34 to one hour,[169] and this was agreed by the Fighting Area and put into effect.[170,171]

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167 2/2815, 61B, 17th October 1932
168 2/2824, OR to DCAS, 1.5.35
169 2/2741, 44A, OR to DCAS, 1.4.35
170 ibid., OR to RDA3, 29.4.35
171 ibid., 53A, Corrigendum No. 1 to Specification F.5/34, 10th May 1935

The restriction to day flying was then removed from F.5/34. Oxland and Sorley erroneously believed that when F.5/34 was under discussion, doubts that an eight-gun fighter could be produced successfully led to "the result that the requirements were restricted to day flying only".[172] This was not so - the limitation to day flying came from the concept of a Fury replacement as described in section 5.3. After consulting the builders of the prototypes, specification F.5/34 was brought fully into line with F.10/35 by a corrigendum which simply said, "For 'day fighter' read 'day and night fighter'".[173]

The marked reduction in endurance has gone largely unnoticed by writers on the development of RAF fighters in the 1930s. M. Bowyer suggests that most of Fighter Command's aircraft had "a duration of about 1 hr 20 min [power unspecified], judged sufficient for the task if radar early warning was effectively employed".[174] But the critical decision on endurance for F.10/35 was made before there could be confidence in the development of an early warning system.

Some of those present at the meeting in March 1935 which considered F.10/35 may have known of the nascent RDF system - it has been said that there was a faint possibility of radiolocation in 1933.[175] Certainly there were contemporary thoughts that early warning of air attacks coming from the East might be obtained by stationing ships or aircraft off-shore,[176,177] and there were fears that an enemy could get warning of an RAF bombing attack when it was 50 miles from his territory.[178] Even so, it is most unlikely that the Air Staff would have

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172 2/2821, 18A, OR to DCAS, 28.5.35
173 2/2741, Corrigendum No. 2 to Specification F.5/34, 15th August 1935
174 Bowyer, Aircraft for the Few, page 11
175 41/39, page 36
176 2/1386, 39A, 6.11.34
177 2/2715, 7E, The Role of the General Purpose Reconnaissance Aircraft, 23.7.35
178 ibid., 7A, The Influence of Tactics upon design of Bombers for the Air Defence of Great Britain, July/August 1935

committed itself to a major change in its operational requirements for zone fighters on the basis of such hopes. A more likely explanation is that fears of attack by fast bombers led it to put maximum speed above all other aspects of fighter performance. This was one of the lessons learnt from the analysis of the Air Exercises of 1931, as noted in chapter 4.5.

No doubt the Air Staff took comfort from the knowledge that an endurance of one hour at maximum rpm for F.10/35 corresponded to three hours at 150 mph.[179] Against unescorted bombers, patrol at that speed might be acceptable, although even then a patrol would have to terminate when there was just sufficient fuel remaining for combat, lest the aircraft became engaged in combat after that time. For example, F.10/35 would have fuel remaining for only 20 mins at normal maximum rpm after two hours patrol at economic speed.[180] If hostile fighters were escorting the bombers, then patrol would need to be at a much higher speed than 150 mph, with a corresponding loss of endurance. Points such as these are illustrated by Price in <u>Fighter Aircraft</u>, where he gives an example of the calculation of endurance and range for a specific operational sortie.[181]

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179 2/2821, 2A

180 PRO: AIR 2/1599, <u>"Defiant" Single Engine Two Seater Day and Night Fighter - Specification F9/35 - Type Requirements</u>, 2B, RDA3 to OR, 27.3.35

181 Price, <u>Fighter Aircraft</u>, pages 35-36

6. THE QUEST FOR FIGHTER FIREPOWER

6.1 INTRODUCTION

The RAF believed that a formation of bombers was capable of putting up a very strong defence, and that attacks by individual fighters would not be successful. It therefore viewed the armament of fighters in the context of the firepower which could be brought to bear simultaneously by a formation. In theory this could give an effective concentration of fire, but it was thought that in practice a fighter pilot could not both maintain close formation and aim his guns. There were seen to be two possible solutions to this dilemma. One was to match the defences of a bomber formation by increasing the number or calibre of guns carried by individual single-seat fighters. This would either obviate the need for formation attacks or give effective long-range unaimed fire from a formation. The other approach was to accept that formation keeping and aimed fire were incompatible, and therefore to separate the functions of pilot and gunner.

Between 1930 and 1935 both of these approaches to the achievement of effective fighter firepower were energetically pursued. In chapter 5 it has been noted that the pursuit of speed for single-seat fixed-gun fighters was coupled with increased armament. It is little known that these fighters were thought unlikely to be successful against formations of bombers, and that for a time priority was given to the development of multi-seat turret fighters (chapter 5.3.1). It was believed that in this way a squadron's firepower could be brought to bear simultaneously on a formation of bombers.

The general issue of fighter firepower was analysed by the DCAS (Ludlow-Hewitt) early in 1933.[1] He was writing after

[1] 2/1323, DCAS to AMSR, 15.3.33

reviewing the results of the "Novel Fighter" competition which is described later in this chapter. Ideas similar to those of Ludlow-Hewitt were later put forward by Sir Robert Brooke-Popham.[2]

Ludlow-Hewitt postulated that the destruction of bombing formations might be achieved by,

"A" Sporadic 'close-in' attack.
"B" Sustained 'lie-off' attack.

He commented that whereas tactic "A" could be delivered by fast single-seaters, these could not give concentrated fire, and had difficulty in making repeated attacks against fast bombers . These problems disappeared with the long-range tactic "B", but this lacked the element of moral shock, which Ludlow-Hewitt saw as the case for retaining "A".

After noting the desirability of increasing the rate of fire of all guns, however mounted, he saw four possible lines of fighter development. These were,

"W" The two-seater with improved stern armament.

"X" A single-seater with extra heavy fore armament for the 'lie-off' astern, (the Thomson type [see section 6.2]).

"Y" A two-seater with swivelling guns forward (possibly with turret) developed for the no allowance position astern and below, (probably on the lines suggested by the A.O.C.-in-C. [see section 6.3]).

"Z" The high performance single-seater fighter for fire shock action.

He considered that all these types must have the highest possible speed and climb, but that X and Y need not have great manoeuvrability.

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[2] 16/305, 78A, Notes on Design and Tactics of A.D.G.B. Fighters, 23rd April 1934

Ludlow-Hewitt proposed that the order of priority for research and experiment should be Z, W, X, Y. He thought that the two single-seat types, X and Z, might be combined, for he expected the development of larger and heavier single-seater fighters to allow more guns without loss of performance. In chapter 5.5 it has been shown that this was found to be so with F.5/34 and F.10/35.

The AMSR (Dowding) largely accepted Ludlow-Hewitt's views, with the caveat that he did not agree that a multi-gun fighter would be restricted to unaimed fire in lie-off attacks. He believed that there should be room for each pilot to take aim.[3] Dowding told Ludlow-Hewitt that, "I think the multi-gun fighter is a force very much to be reckoned with", and that, "Even if we decide not to adopt it ourselves, we must consider the possibility of its adoption by other nations".[4]

Wing Commander Williams (FO1) was consulted, and he suggested that a false impression of the difficulty of repetitive attacks by single-seater fighters had arisen from exercises which had pitted Bulldog fighters of 1928 design against fast Hart bombers of 1930 design. Whereas in a home defence war against France the RAF would employ Furies of 205 mph, Bulldogs of 165 mph and Demons of 185 mph against French bombers of 122 mph with one fixed and two moveable guns. He expected that British and French re-equipment plans would maintain this favourable position. Nevertheless, Williams emphasised that the problem in defending London was not simply that of the destruction of bomber formations but also of catching them in time. He envisaged that against high-speed bombers interception could be made only by single-seaters of the highest possible performance, and consequently of short endurance. Williams was sceptical over the use of two-seater fighters with no speed margin over fast day bombers

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[3] 2/1323, AMSR to DCAS, 20.3.33
[4] ibid., AMSR to DCAS, 17.2.33

of the same date, and of long-range attacks. However, he admitted that should such attacks be needed to break up bomber formations, single-seat fighters with four, six or eight guns could lie astern of a bomber formation and fire at long range.[5]

On the other hand, the DDOI (Peirse) was sceptical of the role of single-seat fighters, however heavy their armament. He took it as generally agreed that single-seat fighters attacking in formation could not keep formation and aim at the same time, and that when attacking individually they could not break up bomber formations. Peirse concluded that the single-seater, however many guns it carried, was "the least useful type of fighter." Even with ten guns it would be up against many more from a bomber formation. Nevertheless, like Dowding, Peirse feared that such fighters would be a serious menace to RAF bombers. These might be faced with deep penetration raids, and relays of enemy fighters could attack them at long range - Peirse said they had done so with success against Independent Air Force raids in 1917-18. For the RAF he favoured a multi-seater fighter with moveable front and rear guns - if the required performance was achievable.[6]

In an attached paper on "Fighter Types and Tactics", the effectiveness of a fighter's two Vickers guns against a bomber's single Lewis was cited, and it was deduced that "the use of eight guns savours of the sledge hammer being used to crack a nut". This contradicted Peirse's own argument that even ten guns would not be enough against the combined firepower of a formation of bombers. More significant is that, at a time when the Air Staff were actively discussing six or eight guns for RAF fighters, they were still thinking in terms of single-gun stations for bombers. This was further illustrated when Ludlow-

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[5] 20/167, FOI to DCAS, March 1933
[6] 20/168, DDOI to DCAS, 28.7.33

Hewitt sought to justify the development of a multi-gun fighter to the CAS in September 1933. He argued that,

> the number of single seater fighters which can attack a large bombing formation simultaneously would probably not exceed one third of the number of bombers, hence the need for the single seater fighter to develop at least four times the fire power of one bomber from the rear gun.[7]

It will be seen in chapter 7 that this was indeed the armament specified for the RAF's own new bombers at the time.

The preceding paragraphs have outlined the policy options and differences of opinion on how fighters could achieve effective firepower. The following sections describe how these led to the specification of single-seat fighters armed with eight machine guns or four 20mm cannon, and to a variety of multi-seat turret fighters.

6.2 SINGLE-SEAT FIGHTER ARMAMENT

6.2.1 The Route to Eight Machine Guns

The history of the armament of the RAF's single-seat fighters in the late 1920s and 1930s has been obscured by the success of the eight-gun Hurricane and Spitfire and the supposed role of Ralph Sorley. For example, Dean says that,

> The fact that these fighters each carried eight Browning machine guns mounted in the wings and not as was customary a smaller number mounted in the fuselage was due to the genius of Air Commodore Ralph Sorley, who pressed this highly novel idea on the designers and on the Air Ministry with most fortunate consequences.[8]

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[7] 2/2741, DCAS to CAS, 5.9.33,
[8] Dean, page 63

Hyde and Divine go further. Hyde claims that the need for eight guns was derived from "Tests which Sorley conducted",[9] and Divine that the Air Ministry,

> had also appointed Squadron Leader Sorley as early as 1930 [sic] to the Operational Requirements Department [which did not exist] of the Air Staff to explore his theories of aerial gunnery. Against considerable internal indifference and some active opposition Sorley developed a theory that air fighting required the maximum concentration of hits within a period of two seconds, ... The story of how Sorley stole an obsolete aircraft to prove his point at Shoeburyness is part of legend.[10]

Quill also refers the success of the Shoeburyness tests, and says, "So eight guns became the policy for RAF fighters and Sorley had it written into what was to become the F.10/35 specification."[11]

Bishop refers to "a persistent one-man campaign" by Sorley.[12] Chaz Bowyer refers to the foresight of Sorley early in 1933. He says that Sorley "calculated that eight machine guns would be essential in fighters if a truly lethal was to be made on an enemy bomber in the two seconds' engagement envisaged".[13]

In his Appendix (dated May 1945) to the Design and Development of Weapons Air Marshal Sir Ralph Sorley described the "Factors Involved in the Conception of the 8-Gun Fighter".[14] He then made no claims of personal involvement. However, in an article in The Times in 1957,[15] (copied in The Spitfire Log[16]) Sorley said that,

> As the individual who was (I think without controversy) responsible for the original eight gun fighter concept, I should like to put on record the

[9] Hyde, page 342
[10] Divine,, page 182
[11] Quill, page 62
[12] Bishop, E., Hurricane, 1986, page 8
[13] Bowyer, C., Spitfire, 1980, page 10
[14] Postan, Appendix VI (page 537)
[15] Sorley, R., "Eight Guns for a Fighter", The Times, 14th September 1957, page 7
[16] Haining, P., The Spitfire Log, 1985, pages 21-26

> sequence of events, so that in times to come there will be no ambiguity ...

This is a remarkable claim, and far from removing ambiguity, Sorley sowed the seeds of confusion.

The issue of fighter armament is one of perceived need *versus* feasibility. From 1926 onwards the need for greatly increased firepower was recognised. By 1934 it had become feasible to meet that need whilst retaining the essential performance characteristics of a fighter. The sequence of events which led to this result is summarised below.

In chapter 4 it has been shown that in 1926 the then AMSR (Sir John Higgins) set in train the development of a six-gun (four wing-mounted) fighter (F.10/27). He foresaw then that as bomber speeds increased, attacking fighters would have only a short time for aimed fire, and thus would need a high volume of fire to be effective. (The then Flight Lieutenant Sorley started his first spell at the Air Ministry in the Supply and Research Department some months after the initiation of this multi-gun fighter project).

In 1927 Newall (then DCAS) called for four guns for the new interception fighter project (F.20/27). Trenchard agreed, and was very annoyed when an administrative mix-up led to only two guns being specified (chapter 4.3.2). In 1930 four guns for the Bulldog replacement were accepted without question, two of which could be wing mounted.[17] Newall at that time emphasised the need for a new type of gun which would be suitable for wing mounting.[18]

In 1931 the Air Staff concurred in the use of the Gloster Multi-Gun (designed to F.10/27) for firing trials,[19] and

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[17] 2/2815, 44A, Specification No. F.7/30, section 6(a) (i) and (ii)
[18] ibid., DCAS to CAS, 31.5.33
[19] 20/169, DCAS to AMSR, 2.2.31

these decisively demonstrated the value of many guns. An Aircraft and Armament Experimental Establishment report concluded that the six-gun aircraft was equivalent to two general purpose fighters.[20] Later in 1931, at Dowding's behest,[21] air firing trials confirmed the ideas behind the inception of the multi-gun fighter. They demonstrated that,

> the multi-gun type of fixed gun single-seater fighter is more likely than is the two-gun single-seater fighter, to produce the density of fire necessary to ensure a hit on a vital part of a target aircraft, in a time which approaches the actual average time during which aerial targets present themselves in air fighting.[22]

Given the above background it is not surprising that many entries to the Novel Fighter competition held in November 1932 (section 6.3) were found to advocate "increased gun power with fixed guns firing forward", and that the judging Committee eliminated all but one of these as not being novel! Nevertheless, the Committee reported that,

> they wish to place on record the large body of opinion this competition discloses in favour of development in this direction. The only limitation appears to be the number of guns and rounds of ammunition which machines can carry.[23]

The fixed-gun fighter entry from Wing Commander A.A.B. Thomson of the Armaments Branch was short-listed, "because it indicated a new conception of this principle".[24] Thomson emphasised the need to destroy an enemy in one attack. To achieve this he proposed an eight-gun single-seat fighter (a twin-engined pusher biplane with four guns mounted in the fuselage and four in the wings). Each gun

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[20] 2/848, 24A, A & AEE Report, Gloster F.10/27. Vickers and Lewis Gun Installations, July 1931, page 20

[21] 2/625, AMSR to DTD and AD/RDArm, 29.8.31

[22] ibid., 16A, A & AEE Report, Long-range Statistical Air Firing Trials to examine the Fire Effect of Multi-gun Aircraft, 27th November 1931

[23] 2/1323, 45A, Report of Committee set up to examine proposals for a Novel Type Fighter, 10th January 1933, section 3

[24] ibid., 45A, section 3

was to be capable of 1,000 rounds per minute. Thomson supported his case by reference to recent firing trials, and claimed that one fighter with many guns would be as effective as a formation with fewer. He stressed the importance of speed and of a steady gun platform.[25]

Thomson's entry was not taken further because in the then state of aircraft development it was limited to 200 rounds per gun,[26] and to achieve even that he proposed to limit the weight of pilots to eight stone[27] - a suggestion which Williams thought to be "fantastic!"[28] Perhaps so, but in similar discussions in the United States Army Air Corps the thought of restricting the size of pilots was also considered.[29]

In forwarding his department's entries in November 1932, Dowding wrote that, "I cordially endorse the contention [in Thomson's entry] .... that complete destruction of enemy aircraft in one attack must be aimed at." He said that,

> The failure of single seater fighters during the war to develop decisive fire from the rear against bomber formations has in my opinion led umpires in peacetime manoeuvres to impose unduly drastic casualties on fighters attacking in these circumstances. The result has been that we have been driven to explore other lines of attack and the two-seater fighter has been developed ...

Dowding added that the great advantage of the multi-gun fighter was that it would not be at a disadvantage in combat with other fighters, and enclosed a graph to demonstrate the hitting power of six Darne[30] guns.[31]

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25 ibid., Part IV, Thomson's entry, 19.11.32

26 ibid., Appendix 45A, section 6.(a)

27 ibid., Part IV, Thomson's entry

28 20/167, F01 to DCAS, 18.18.33

29 Greer, page 86

30 a French machine gun then being evaluated by the RAF (Wallace, G.F., The Guns of the Royal Air Force 1939-45, 1972, page 56)

31 2/1323, Part IV, AMSR to SD2, 25.11.32

At the same time, in late 1932, as discussed in chapter 5.3.1, the DCAS (Burnett) advocated six guns for the Fury replacement, and in March 1933 Williams considered an eight-gun fighter in response to Ludlow-Hewitt's appraisal of fighter development policy.

Sorley did not join the Air Staff until 17th January 1933. It is easily established from the Air Force Lists that in 1930 he was a student at the RAF Staff College, and in 1931 and 1932 he was Commanding Officer of No. 8 (Bomber) Squadron which was stationed at Khormaksar, Aden Command. That in 1934 and 1935 Sorley made important contributions to the evolution of the Hurricane and Spitfire has been shown in chapter 5, but claims that his advocacy of multiple wing-mounted guns for fighters was novel in 1934 are unfounded, as is his description of the events which led to the eight-gun fighters.

It was in the summer of 1934 that a decision had to be taken on the armament to be specified for the delayed Fury replacement (F.5/34) - other aspects of that project have been discussed in the previous chapter. The then Squadron Leader Sorley put to the DCAS a somewhat half-hearted recommendation for eight guns. He wrote,

> I do not think anything less than six guns should be considered. We shall always be able to reduce the number of guns carried in war if it is found necessary to increase performance, or if good results are being obtained with a fewer number of guns than 8, but if we call for less we cannot increase them at will.[32]

There is conflicting evidence as to when the actual decision to call for eight guns was made. Keith, who was Assistant Director (Armament Research and Development) in 1934, says that Captain F.W. Hill, the civilian gunnery expert on his staff, had analysed the results of careful

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[32] 2/2741, OR to DCAS, 5.7.34

firing tests carried out early in 1933. Predictions were made of the density of hits that would be required to do lethal damage to an aircraft, and it was concluded that contemporary tactics and armament could not be effective. Keith says that he persuaded Tedder, then Director of Training, to hold an informal conference to consider gunnery problems on 19th July 1934. This was two weeks after Sorley's minute which is quoted above.

Keith says the meeting, which was attended by Sorley, was shown graphs of Hill's analysis of the firing trials, and that far-reaching "decisions" were taken. It was concluded that eight guns firing at 1,000 rounds per minute were required. Keith says that he had to carry this argument to high quarters before authority was given.[33] No doubt he did, for an informal meeting chaired by the Director of Training could surely not have decided such an issue, and there was indeed opposition from a high place to the proposal to call for eight guns.

On 27th July 1934, Ludlow-Hewitt sent the draft F.5/34 requirements to the AOC-in-C ADGB, and asked for his views.[34] Air Marshal Sir Robert Brooke-Popham's lengthy reply included the phrase, "I think 8 guns is going a bit too far", and this is quoted by Wykeham[35], Bishop,[36] C.Bowyer[37] and Wood and Dempster as an example of the opposition to eight guns. Wood and Dempster say that the proposal created a "furore amongst older officers like Air Chief Marshal Sir Robert Brooke-Popham".[38] But it seems that claims of opposition to eight guns from many senior officers are supported by many references to a remark from one officer.

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[33] Keith C.H., I Hold My Aim, 1946, pages 78-79
[34] 2/2741, 24A, DCAS to AOC-in-C, 27th July 1934
[35] Wykeham, page 62
[36] Bishop, page 8
[37] Bowyer, C., Spitfire, 1980, page 10
[38] Wood and Dempster, page 87

Brooke-Popham's remark was in the context that eight guns would give a lot of head resistance, and that "most people in the Fighting Area wanted guns in the cockpit", which would not be possible with eight guns. Otherwise his comments on the draft requirements were forward looking. He referred to talks with an American designer in which 300-350 mph was mentioned, and suggested that the maximum speed in the draft requirements should be increased from 265 to 280 mph. He said that the 1934 Air Exercises had shown that climb was not so important, and supported the compromise in favour of speed.[39]

Brooke-Popham's objections to eight guns were read to a meeting of the 'Operational Requirements Committee'[40] held on 9th August 1934 to discuss the Air Staff's draft requirements for F.5/34. The meeting was told that his concern about the head resistance of eight guns had been dealt with.

It is evident that Brooke-Popham and his staff had commented on the proposal to have eight guns from the point of view of their experience of biplanes and of Vickers and Lewis machine guns. It would have been difficult to mount these guns and their ammunition on the thin wings of a biplane without a significant drag penalty, and very difficult to mount eight of them in a fuselage so that pilots had access to the unreliable Vickers gun in order to clear blockages. But, as discussed in chapter 5, for some years the Air Ministry had envisaged that future fighters would have a cantilever monoplane wing, and this would be thick enough to house eight guns of a new and reliable type, and their ammunition.

The Minutes of the meeting on F.5/34 record that it was, "unanimous that the slight sacrifice [from six guns] of

[39] 2/2741, 25A, AOC-in-C to DCAS, 1st August 1934

[40] ibid., 26A, OR to AMSR, DTD, DSD, DoO, DDOI, Plans and RDA4, 3.8.34, inviting them to the meeting

one mile per hour was more than counterbalanced by the great advantage of additional guns", and

> IT WAS AGREED that 8 guns should be aimed at on grounds of shorter time to obtain the required density and the improvement in range which was obtainable with more guns.[41]

When he reported this conclusion to the CAS, Ludlow-Hewitt attached the graphs (Hill's) provided by the AMSR's Department on which it was based.[42] These showed, for six and eight guns, each capable of 1,200 rounds per minute, the length of burst required to obtain a vital hit plotted against range.[43] They confirmed Thomson's conclusions of November 1932. Yet Sorley claimed that it was he who had come to the conclusion that eight guns were needed, "After much arithmetic and burning of midnight oil".[44]

Sorley's version of these events is different in other respects. He wrote that after much discussion with his friends in 1933, he was satisfied that his concept was right, but that as it,

> would produce a totally different fighter from anything the fighter pilots were accustomed to. I was cautious, therefore, where I discussed these ideas in the early stages, for fear of arousing reaction too soon; and to obtain confirmation I arranged with Major Thompson, ... , that we would obtain an obsolete aircraft, set it up on a range, mount eight guns at 400 yards, fire bursts of two seconds with solid and explosive ammunition, and assess what happened. This we did on the ranges at Shoebury, and to my joy the effect was all that I had imagined.

Sorley continued that, "With that bit of evidence behind me, I think the specification F5/34 came out into the open, and many meetings were held where, finally, unorthodoxy carried the day."[45]

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41 ibid., [60A], Extract from Minutes, 9th August 1934
42 ibid., DCAS to CAS, 5.9.34
43 ibid., 24B
44 Haining, page 22
45 ibid., page 24

This impressive story of original theory - secret experiment - doubters routed, is marred by the fact that by 1957 Sorley's memory of the actual sequence of events seems to have gone sadly awry. It was many months after the decision to call for eight guns for F.5/34, and after general circulation of that specification, that firing trials with eight machine guns were carried out at Shoeburyness - and not in secret.

Air Ministry files of the time show that in December 1934, in a paper for the Air Fighting Committee, "Practical trials of firing explosive bullets from 4 or 8 machine guns were proposed by O.R.".[46] This paper is written in the first person - presumably by Sorley, for it refers to a visit by the writer to France to see a 20mm gun. Sorley says that he visited France for this purpose, "Before deciding to specify eight .303 machine guns".[47]

A later paper in the same style reported to the committee that successful trials with eight guns firing solid and explosive rounds had taken place at Shoeburyness on 19th June 1935,[48] i.e., ten months after the unanimous agreement of the Operational Requirements Committee to eight guns for F.5/34, seven months after issue of the specification, and some months after prototypes had been ordered. Indeed, the trials took place after the issue of requirement F.10/35 in April 1935 (which also called for eight guns), and after Sorley himself had suggested the conversion of the Hawker and Supermarine experimental fighters to F.10/35.

It happened, as explained in chapter 5.4.3, that issue of specification F.10/35 was overtaken by agreement to Sorley's proposal, and this led to consideration of a

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[46] PRO: AIR 5/1137, Papers for Air Fighting Committee, A.F.C./6, Brief Review by O.R. of the use for air fighting of a Gun of larger Calibre than Machine Guns, 14.12.34, para.13
[47] Haining, page 24
[48] 5/1137, A.F.C./15, "Further Review by O.R on the question of Guns .....", 26.7.35

recast of F.10/35. Sorley's novel contribution to fighter armament was to come with this project.

6.2.2 The Cannon Fighter

When doubt was cast on the issue of specification F.10/35, the first thoughts of both the Air Staff (Oxland/Sorley) and the DTD (Verney) regarding its recast were to attempt to employ the large C.O.W. gun in a "No Allowance Fighter".[49,50]

No allowance shooting had for many years been seen as a means of making long range attacks on bombers. It was based upon the principle that,

> It is possible to find an angle of fire so that the effect of an aircraft's forward speed exactly counterbalances the effect of gravity, allowing the bullet to travel along a trajectory which is almost a straight line, for a surprisingly great range.[51]

Thus if a fighter flew below and behind a bomber, and at the same course and speed, and with its guns at the appropriate upward angle, the gunner would need to make no allowance for gravity, aerodynamics or relative speed.[52]

The CAS (Ellington) saw the proposed no allowance C.O.W. gun fighter alternatives to F.10/35 when he approved withdrawal of the specification in June 1935. His comment on them had far-reaching effects. Ellington minuted that,

> We should however, be clear as to our attitude to smaller calibre guns than the C.O.W. If other powers are ignoring the St. Petersburg Convention(?) [sic]

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49 2/2821, 18A, OR to DCAS, 28.5.35

50 ibid., DTD to OR and DCAS (through AMSR), "Single Seater Day and Night Fighter specification F.10/35", 21st May 1935

51 Keith, page 53

52 PRO: 10/1430, Manual of Air Tactics, 1937, chapter VII, para.19, No-Allowance Shooting

> in respect of the weight of explosive projectiles, are we to do the same?[53]

The Convention agreement was that explosives would not be used in projectiles which weighed less than 400 grams,[54] and therefore did not apply to the 1½ pounder (700 grams) C.O.W. gun. The significance of the 400 gram limit had been noted in an Operational Requirements note of December 1934, but this nevertheless proposed firing trials with explosive ammunition in 0.303in machine guns.[55]

The Air Ministry was aware of developments in Switzerland and France of 20mm and 23mm cannon which fired an explosive shell of much less than 400 grams. The French Hispano gun was designed specifically for mounting on an aircraft engine. In I Hold My Aim Keith has described his investigation and assessment of these developments.[56] Ellington's apparent willingness to ignore the St. Petersburg Convention appears to have prompted consideration of such weapons by the RAF, for when Sorley proposed a new version of F.10/35 he dropped the earlier proposals to use the C.O.W. gun. He referred to an Operational Requirements' review of fighter armament (presumably A.F.C./15, referenced above), which "advocated that we should develop a multi-cannon armament".

Sorley suggested that the quickest way to do this would be to convert the unissued F.10/35 specification by substituting four cannon for eight machine guns in its "Armament" paragraphs. He thought that,

> In general design the aircraft need not differ essentially from those building to 5/34, 36/34 and 37/34 and perhaps D.T.D. may think the easiest and quickest way to fulfil the requirements would be to have additional wings built for one or other of these types.[57]

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53 2/2821 CAS to DCAS, 4.6.35

54 Wallace, pages 31-32

55 5/1137, A.F.C./6, paras. 2 and 13

56 Keith, Chapter 8

57 2/2821, 26B, Specification F.10/35 (Suspended), 23rd August [1935]

The DCAS (Courtney) sought Ellington's approval for such a recast of F.10/35. He foresaw that mounting heavy guns in wings would be a problem, but said that one cannon mounted on the engine,

> is only a first and somewhat inadequate step towards heavier armament and offers such a meagre density of fire that its adoption would not provide an adequate armament.

He added, "If we tackle this new problem quickly and successfully we should have a fighter superior to anything we know of elsewhere".[58]

Ellington agreed to this proposal,[59] and an Air Staff Requirement was sent to aircraft firms on 1st February 1936 as Appendix "B" of the (future) specification F.37/35 (amended from 10/35). It was entitled "Amended Requirements for Single Engine, Single-Seater Day and Night Fighter",[60] and called for a fighter with sufficient (at least four) 20mm guns to give a decisive result, and at longer ranges, than would machine guns. There is no evidence that this project had been considered by the Operational Requirements Committee.

When the specification itself was issued on 15th February 1936 the single engine requirement was dropped.[61] The design ordered for development was the twin-engined Westland Whirlwind, with the four cannon mounted in the fuselage - so by-passing the expected problems of wing mounting. The Whirlwind was delayed in development, and in 1939 Sorley's idea of installing cannon in the wings of the Hurricane and Spitfire was acted upon.[62] In this way

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[58] ibid., DCAS to CAS, 11.11.35
[59] ibid., CAS to DCAS, 13.11.35
[60] ibid., 43B
[61] ibid., 56B, Specification F.37/35. Single-seat day and night fighter, issued 15th February 1936
[62] Postan, pages 108-109

the products of the high-speed research programme also filled the role of the cannon fighter.

The development of the machine guns and 20mm cannon which were a vital ingredient of the eight-gun and cannon fighters is described by Wallace[63], by Keith[64], and in the Air Historical Branch Narrative on Armament, Vol. II: Guns, Gunsights, Ammunition and Pyrotechnics.[65]

6.3 FORMATION FIREPOWER

In the Introduction to this chapter reference is made to doubts about the effectiveness of fixed-gun fighters - even with eight or ten guns - against formations of bombers. The words of Air Chief Marshal Sir Geoffrey Salmond, when AOC-in-C of the Air Defence of Great Britain in 1933, show how widespread these doubts were. In referring to the Novel Fighter competition to be described below, he wrote,

> It will be recognised that in practically all the proposals put forward by the various officers under my Command there is a note of pessimism as to the ability of present day fighters to compete successfully with hostile bombing formations. This is a clear warning that there is something wrong in our policy.
>
> I would suggest that the fixed gun single seater fighter, which is the cause of this pessimism, was designed in the first instance rather for the needs of air fighting in France in 1916-18 than for the purpose of home defence fighting.

Salmond deduced that to break up enemy bomber formations in the short time available, "the design of the home defence fighter and the tactics employed should be such as to produce the maximum fire effect in the minimum time". Since the need for concentration required that fighters

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63 Wallace

64 Keith, chapters 7 and 8

65 PRO: AIR 41/82

attacked in formation, Salmon saw this as ruling out any form of fixed gun, because, as quoted in chapter 5.1, "A pilot cannot aim a gun and at the same time accurately maintain his position in formation".[66]

This section examines the attempts to find a type of fighter which, by attacking in formation, could bring a great concentration of fire to bear on an enemy bomber formation. This little known aspect of RAF fighter policy is traced through the Bright Ideas, or Novel, Fighter competition, Air Chief Marshal Ellington's "CAS" fighter project, the development of the Boulton Paul Defiant, and plans to fit movable guns in the wings of the Hurricane and Spitfire.

6.3.1 Bright Ideas and the Novel Fighter

In October 1930 Wing Commander Maund, newly appointed as head of Flying Operations 1 on the Air Staff, re-opened the search for a fighter type which would be effective when fighting in formation. He suggested that the "period of grace" which had been imposed on discussions of the Bulldog replacement (F.7/30) in November 1930 (chapter 5.2) should be used to review fighter development. He argued that although the single-seat multi-gun approach was the best available, it was not satisfactory. To search for something better, Maund suggested that the problem of driving away bomber formations should be put to the aircraft industry and made the subject of an experimental tender.[67] A year later Maund re-activated this idea. He sent the DCAS (Burnett) a scheme for what he called a "'Bright Idea' Fighter". Maund put forward a procedure for a tender competition to meet a set of "ideal

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[66] 2/1323, 46A, AOC-in-C ADGB to Air Ministry, Design of Home Defence Fighter, 24th January 1933, sections 1 and 4

[67] 20/167, Problems of Fighters for Home Defence, undated and unsigned; attributed to FO1 and dated November 1930 from a reference to a minute in AIR 2/2815 of that month

operational requirements".[68] The final form of these is quoted later - it differed little from Maund's first ideas.

Maund emphasised the need for fighters to attack in formation, but stressed the danger of collision when formation attacks were attempted by single-seat fighters. He drew attention to the views of the AOC-in-C of the ADGB following a recent Court of Inquiry into such an accident.[69]

Air Marshal Sir Edward Ellington had noted that whereas in fighter/bomber affiliation exercises, and in the study and practice of fighter tactics, only the formation leader took aim, the Inquiry arose from an experimental fighter attack in which each pilot aimed at his opposite number. This required the pilots to take their eyes off their formation leader, and this was seen to lead to a grave risk of collision - given the "field of vision afforded by the Bulldog". (The concern with fighting view as been discussed in respect of the F.7/30 requirements). Ellington had consulted his twelve fighter squadron commanders, and reported that five felt that the risk of collision should be taken in war, but only three thought it acceptable in peacetime training. Ellington concluded that the risk was not acceptable, and that,

> we must modify the type of aircraft with which we equip our fighter squadrons and endeavour to design one which will enable the front gun to be worked by a gunner who is not the pilot.[70]

As described later in this chapter, he was to pursue this idea after he had been appointed Chief of the Air Staff.

In December 1931 Burnett (DCAS) put Maund's 'Bright Idea' Fighter scheme to Dowding (AMSR), with the comment that,

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68 20/68, page 89, Appendix A, "Bright Idea" Fighter Aircraft, attached to FO1 to DCAS, 1.10.31,

69 2/1323, 2A, note by Maund, undated

70 ibid., 1A, AOC-in-C to Secretary, Air Ministry, 24th September 1931, para.8

> I feel that while we should continue the present efforts to find a solution by means of increased fire power from single-seaters and by still further tactical experiments, we might also try to attack the problem another way, namely, by thinking out other possible forms of fighter not subject to the well known limitations of single-seaters.

He suggested getting "the trade" to help with new ideas, as proposed by Maund.[71]

Dowding objected to putting such a question to industry. He thought it would be more useful to seek the opinions of the Fighting Area of the ADGB and of the Director of Training.[72]

Burnett took up this suggestion and sent Maund's paper to the Director of Training (Air Commodore W.G.S. Mitchell)[73] and the AOC-in-C (Ellington).[74] He said that his aim was "to see if the technical development of the last ten years has enabled other forms of fighters to be evolved which will meet our requirements more effectively than the present types."

Mitchell agreed that pilots could not get concentration of fire and fly their aircraft (in formation) at the same time, and concluded that the solution lay with either a multi-gun fighter or a two or three seat fighter.[75] Ellington welcomed "the broad scale on which the proposed operational requirements governing the design of fighter aircraft have been drawn up." He considered that it would give designers a "really free hand and produce a fighter best suited to our needs".[76]

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[71] ibid., DCAS to AMSR, 2.12.31
[72] ibid., AMSR to DTD, 8.12.31
[73] ibid., DCAS to DoT, 28.12.31
[74] ibid., 10A, DDOI to AOC-in-C, 24th March 1924
[75] ibid., DoT to DCAS, 13.2.32
[76] ibid., 11A, AOC-in-C ADGB to Air Ministry, 22nd April 1932

With this support, in April 1932 Burnett obtained the Chief of the Air Staff's agreement to proceeding with Maund's scheme,[77,78] but Dowding repeated his objection to inviting industry to participate.[79] He insisted that it was "highly improbable that aircraft designers will be able to hit on any tactical method which evades the united intelligence of the Service".[80] Dowding's view prevailed, and he and Burnett agreed to hold a "preliminary unofficial competition" restricted to the Service.[81]

The competition was launched by the Directorate of Staff Duties through the issue of a Memorandum calling for "Suggestions for an Improved Form of Fighter Aircraft", with entries required by 21st November 1932.[82] The Memorandum gave the operational requirements which "those making suggestions should attempt to meet as far as they can." These were,

> (i) Fighters should be able, when in squadron formation or tactically deployed, to open simultaneous fire on hostile formations and to sustain the attack until a decision is reached.
>
> (ii) The armament layout should enable fighters to employ tactics which will deflect enemy formations from their course and away from their objectives during the action stage.
>
> (iii) The design of aircraft and armament layout should permit action to be joined from as many directions as possible with a minimum of preliminary manoeuvre and loss of time.
>
> (iv) Fighters should be able successfully to engage fighters as well as bombers.
>
> (v) An adequate margin of performance over contemporary bombers is needed both as regards speed and manoeuvrability together with the highest possible rate of climb.

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77 ibid., DCAS to CAS, 29.4.32
78 ibid., CAS [to DCAS], 2.5.32
79 ibid., AMSR to DCAS, 28.6.32
80 ibid., AMSR to DCAS, 22.7.32
81 ibid., DCAS to AMSR 30.8.32
82 ibid., 27B

(vi) Ability to operate by night as well as by day and to carry the required equipment of a zone fighter.

(vii) Special attention to be given to the freedom of arcs of fire from obstructions such as tail planes, etc. if movable guns are employed.

(viii) Machine Guns in movable mountings should be capable of being operated under all conditions.

The requirements to fight in formation and from many directions implied a multi-seat aircraft, yet all the attributes of a zone single-seater fighter were also required. Bright ideas were certainly needed!

A large number of entries were received, and a Committee was set up to judge them. Maund was appointed chairman and the other members were Wing Commander A.T. Williams (who was scheduled to replace Maund as head of Flying Operations 1), Squadron Leader R.B. Mansell and Captain R.N. Liptrot from the Research and Development (Aircraft) Branch, and Major H.S.V. Thompson of the Armaments Branch.

The committee met on 10th January 1933 and immediately eliminated many entries because they were vague or impractical, or duplicated ideas which were included in current developments.[83] It has been noted earlier that Thomson's eight-gun fighter proposal was short-listed, but rejected after further consideration.

Four entries remained, and these fell into two classes:-

(a) Those with a turret mounted to cover the upper hemisphere, or rather most of it, and

(b) An aircraft with special turret in the nose to enable it to fire not only in the front hemisphere but through a considerable proportion of the remaining area.[84]

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[83] ibid., 45A, Report of a Committee set up to examine proposals for a Novel Type Fighter, para.3

[84] ibid., 45A, para. 7

The committee considered that the most important zone of attack was the forward hemisphere and therefore decided to eliminate the two entries in class (a). Its reasons were that in one case the upper turret could not reinforce the front guns, and in the other this would be possible only by sacrificing the pilot's view aft. Even so it recommended the latter proposal should a Demon replacement be decided upon in the future. (Brew asserts that the front-turret type (b) was a Demon replacement,[85] but this was clearly not so.)

Ironically, the two types rejected from the final short list, fighters with eight fixed guns or with a midships turret, actually became the equipment of Fighter Command when it entered the war in 1939.

Two entries remained, Maund's and that from the Directorate of Technical Development. Both had proposed a two-seater aircraft with a specially designed front turret to give a wide field of fire, and with two wing-mounted fixed guns. To accommodate the front turret Maund sketched a tailless monoplane single-engined pusher aircraft, and the DTD's staff proposed a monoplane twin-engined pusher of otherwise conventional layout.[86] Both hoped to get two or more machine guns in the turret. The committee considered that the front turret configuration gave "almost complete freedom in the choice of tactics for the attack". It could not decide which was the best of the two proposals. The tailless design appeared to offer a wider zone of fire and no loss of performance compared with a single-seat fighter, but the twin-engined pusher could be developed along proven aerodynamic lines.[87] The committee recommended,

(a) That the trade be asked to produce experimental two-seater fighters with front gun turrets.

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85 Brew, page 236

86 2/1323, 42B, Most Promising Proposals in the Competition

87 ibid., 45A, paras. 9-11

> (b) That they be shewn the outlines of both D.T.D.'s and F.O.1's proposals to give them an idea on general lines only of what is in mind.

A final comment concerned those entries which proposed guns which, "could be moved up to the 45° no allowance position". It was thought that this would be particularly useful at night, and should be looked into.[88] Although outside the scope of the current research, it may be noted that the Luftwaffe employed a similar method to attack RAF night bombers during the Second World War, although not employing no allowance principles.[89]

As the competition was concluding early in 1933, Maund left the Air Staff to take command of the Aircraft and Armament Experimental Establishment following his promotion to Group Captain. His successor as FO1 (Williams) reviewed the history of the Bright Ideas scheme and expressed disappointment with the results of the competition and regret that the views of the aircraft industry had not been obtained. He pointed out that the fighters recommended by the committee did not meet the requirement to be "able successfully to engage fighters as well as bombers, in as much as they are somewhat restricted in rear defence".[90] Sir Geoffrey Salmond had taken a different view of this aspect in his comments on the entries from the ADGB quoted at the beginning of this section. In supporting the concept of a fighter with a front turret he said that,

> Defence, however, should not be allowed to play too important a role in the design of home defence fighters, since enemy fighters are not likely to operate frequently or in force over our defended zones. In addition defence against enemy fighters is provided by the 'interceptor' class of fighter.[91]

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88 ibid., 45A, paras. 12 and 13

89 Hinchliffe, P., The Other Battle: Luftwaffe Night Aces versus Bomber Command, 1996, pages 137-138

90 20/167, FO1 to DCAS through AMSR, 13.2.33,

91 2/1323, 46A, section 6

(As discussed in chapter 4.3.2, this was not part of the role initially planned for the interception class.)

Dowding, who as the Air Member for Supply and Research, would have to implement the Committee's recommendations, accepted them with some reluctance.[92] He drew attention to his comment on the front turret entry from his department - that it would be at the mercy of single-seat fighters. Dowding had then said that, "I do not consider it necessary at the present moment to adopt any new design. I think we have in the multi-gun fighter a weapon to our hand which will prove adequate to our requirements if properly employed."[93] The multi-gun fighter did indeed prove adequate in 1940 when Dowding employed it.

Specification F.5/33 for a fighter with a front turret was drawn up, and outlines of the Maund and DTD proposals were included.[94] Before it was put out to tender, there arose a proposal for an even more extreme type of fighter design.

6.3.2 Ellington's Fighter

Sir Edward Ellington was appointed Chief of the Air Staff in May 1933. Soon after his appointment he read the minute (discussed in section 6.1) in which the DCAS (Ludlow-Hewitt) set out priorities for future research and experiment into types of fighter. Ellington saw that the two-seat fighter with a front turret was put last in priority for future research (funds for the Novel Fighter had already been set aside[95]), and in particular behind research into increased fire power for single-seat fighters. This was contrary to the emphasis Ellington had placed on the need to separate pilot and gunner when he

[92] ibid., AMSR to DCAS, 17.2.33
[93] ibid., Part IV, AMSR to SD2, 25.11.32
[94] ibid., 54A, DTD to DDTD, AD/RDA, RDA3, 5.4.33
[95] ibid., DCAS to AMSR, 15.3.33, para.12

was AOC-in-C ADGB in 1931. He asked for more urgency on this idea, and wrote,

> What I think is wanted is an aeroplane which can be fought against an attack from both the front and from behind, in formation; and for this a two-pilot aircraft is required, so that one pilot can maintain the place of his aircraft in the formation while the other fights the front or rear gun or guns as the case may be.[96]

It might be thought that Ellington's proposal fell into the class of those defined as "so vague and unpractical [sic] as not to warrant serious consideration" by the Novel Fighter competition judging committee,[97] (although Maund himself had at one time suggested a fighter with guns at "both ends of the fuselage"[98]). But Ellington was head of the RAF and, as discussed in chapter 5.3.1, his proposal was given overriding priority.

Ellington was persuaded that to switch control of an aircraft between two pilots in the course of an action might be impractical. Alternatives were proposed of either a three-seat aircraft with one pilot and two gunners,[99] or a two-seater with one pilot and a gunner to move between fore and aft turrets as the course of an engagement dictated.[100] At one time attempts were made to treat the "CAS" type as being primarily for overseas or escort use, with the Bright Idea or "Novel" type for home defence. In rejecting this Ellington stressed that the prime requirement was for a fighter which could be fought in formation, and that the rear turret was not for rear defence - it was to attack an enemy from the front and flank. He did concede that, "I do not expect that the first attempt will produce a very successful machine".[101]

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[96] ibid., CAS to DCAS, 9.5.33,
[97] ibid., 45A, para.4
[98] 20/68, pages 75-76, FO1 to DCAS, 29.9.32
[99] 20/167,, FO1 to DCAS, 11.5.33
[100] ibid., FO1 to DCAS, July 1933
[101] 2/681, CAS to DCAS, 14.9.33

An Air Staff Requirement (F.22/33) for an experimental fighter with movable front and rear single Lewis guns which need not be fireable simultaneously was written to cover Ellington's project.[102] In approving this he said that he wanted designers to be given a free hand. He did not object to a three seater as a third choice after the two pilot or gunner moving to-and-fro options.[103]

There was little enthusiasm in responding to specification F.22/33, or to the Novel Fighter specification, F.5/33.[104] Designers believed that the front turret and two engines, common to both projects (Maund's pterodactyl scheme was not taken up), would give such high drag as to make a useful performance impossible to achieve.[105] Indeed, the CAS type had evolved into a three-seater with two gunners, which the designer - Fairey - suggested might also serve as a bomber.[106] Ellington himself observed that this was unlikely to give more information than "an adaptation of the twin-engine day bomber, B.9/32 similar to that which made a Demon out of a Hart."[107] This comment invites the spectre of the Battle of Britain fought by Fighter Command equipped with a fighter variant of the Wellington bomber.

Prototypes for both types of multi-seat fighter were ordered, but as designs progressed it became clear that their performance would be inadequate. in June 1935 the DCAS (Courtney) sought Ellington's permission to cancel F.22/33. He suggested that the new turret-fighter project F.9/35 (see below) would do the job intended by Ellington's project.[108] Ellington agreed to the cancellation, remarking that he had wanted an aircraft which "could be flown in formation and could be fought in

102 ibid., 5A
103 ibid., CAS to AMSR, 3.10.33
104 Specification held by Air Historical Branch, Ministry of Defence, issued 22nd December 1933
105 20/167, FO1 to DCAS, 16.3.34
106 2/681, 16A, Tender Designs to Specification No. F.22/33, DTD to AMSR, 31.7.34
107 ibid., 17B, CAS to DCAS, 29.8.34
108 ibid., 19A, Cancellation of F.22/33, DCAS to CAS, 6.6.35

formation both to the front and to the rear. I did not want a 3-seater, but a two-pilot aircraft".[109]

6.3.3 Genesis of the Defiant

The project F.9/35 referred to by Courtney was the type "W" specified in Ludlow-Hewitt's review of fighter requirements - a two-seater with improved stern armament. In October 1934 the DDOI (Harris) concluded that the twin-engined Novel and CAS fighters were unlikely to go to production because of their low performance. He proposed that a new two-seater fighter, with a single-engine, should be included in the 1935 Experimental Aircraft Programme.[110] This was agreed.[111]

M. Bowyer maintains that Boulton & Paul, "floated the idea of a turret fighter to replace the biplane Hawker Demon", after they had bought a French designed turret in 1934. He says that this aroused Air Ministry interest to produce F.9/35.[112] But Brew says that the rights to the French SAMM turret were bought on 23rd November 1935[113] - over a year after Harris proposed development of a single-engine two-seat fighter. There is no mention of Boulton Paul[114] in the Air Ministry's discussion of the requirements of F.9/35 in 1935.

A draft "Air Staff Requirement for a Single Engine Two-seater Day and Night Fighter"[115] was discussed by the Operational Requirements Committee on 3rd April 1935. The conclusions of this meeting and their aftermath underline the quandary resulting from the desire for a multi-seat

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109 ibid., 19A, CAS to DCAS, 7.6.35

110 2/716, DDOI (for DCAS) to CAS, 12.10.[34], page 3 para.(c)

111 ibid., 6B, Minutes of Conference held on 16th October 1934 on Experimental Aircraft Programme;

112 Bowyer, Aircraft for the Few, page 14

113 Brew, page 236

114 the company's name was changed from Boulton & Paul on 30th June 1934; Brew, page 62

115 PRO: AIR 2/1599, "Defiant" Single Engine Two Seater Day and Night Fighter - Specification F9/35 - Type Requirements, last paper in the file, unnumbered and undated

fighter coupled with the failure to agree viable tactics for its use.

The Air Staff Requirement called for a fighter which,

> can bring fire to bear from a moveable battery of at least four machine guns over the upper hemisphere.......; thus conferring on it the ability to attack from below and behind, below and in front, or on the flank of an enemy formation, at the same time enabling the batteries of all fighters to be trained on to the target simultaneously while in formation.

No fixed forward guns were specified, on the grounds that it was "Undesirable to split the armament".[116] This echoed a remark of the Director of Training when he had been asked for his views on the ideal operational requirements of Maund's Bright Idea Fighter in 1932. He observed that, "The drawback of the present two-seater fighter (Hart) is that the pilot has a front gun, and in a frontal attack on a bombing formation the same difficulties arise as with a S.S.F. with fixed guns."[117] (By "Hart" Mitchell meant the Hart Fighter Variant later named Demon.)

How having some fixed front guns could be seen as a drawback is difficult to understand - unless one accepts Spick's view that it, "removed temptation from the pilot who might otherwise have tried to start his own private war."[118] Even the exotic projects for front turret fighters which followed from the Novel Fighter competition had some fixed forward armament.[119] Indeed, as has been noted, the two short-listed entries with midships turrets were discarded because their turrets could not reinforce their front guns. Furthermore, when in 1933 Peirse had argued the case for a two-seat fighter, he had envisaged the ideal fighter as having a four-gun turret behind the pilot plus two fixed guns for the pilot. Then in dogfight

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116 ibid., section 3. Armament (a) guns

117 2/1323, DoT to DCAS, 13.2.32

118 Spick, M., Fighter Pilot Tactics, 1983, page 50

119 2/1323, 54A, DTD to DDTD, 5.4.33

the turret could be fixed to give six guns straight ahead.[120] Despite these earlier views, when F.9/35 was discussed by the Operational Requirements Committee the Minutes record no discussion of the absence of front guns or of the proposed tactics.[121] But Keith, who attended in his capacity as Head of the Armaments branch, wrote of these matters that, "some hard things had been said by several successful single-seater fighters [pilots] of the last war."[122]

Although the F.9/35 project was initiated because it was thought that a single-engined aircraft would have a better performance than was expected of the two twin-engined fighters under development, the committee decided to allow two engines. Inevitably this led to a proposal from the department of the Air Member for Research and Development (AMRD) that the Armstrong Whitworth twin-engined Novel Fighter design to F.5/33 should be changed to meet the requirements of F.9/35 - it was hoped to save the money which had been spent on F.5/33.[123] The company believed that they could meet the performance requirements of F.9/35 and asked if a front turret was acceptable.[124]

This query led to a discussion of turret position and tactics which made a nonsense of the previous three years effort on the promotion of multi-seat fighters. Courtney (DCAS) claimed that the RAF did not need the downward firing capability of the front turret, but did want the beam fire and rear defence given by a midships turret.[125] This was tantamount to saying that the considerable investment in the Novel and CAS types, and the priority given to them, were unsoundly based. In both these projects the importance of fire in the forward hemisphere

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120 20/168, Fighter Types and Tactics, 28th July 1933

121 2/1599, Minutes of Conference to consider "Operational Requirements of a new type Two-Seater Day and Night Fighter (Specification F/9/35), 3rd April 1935

122 Keith, page 109

123 2/1599, 27A, DCAS to CAS, 14.11.35

124 ibid., Armstrong Whitworth Aircraft to Air Ministry, 15th October 1935

125 ibid., 27A, DCAS to CAS, 14.11.35

had been stressed. Ellington, who had strongly pressed for a fighter with front and rear turrets, argued that if fighters had to dive on bombers they would need downward fire,[126] but Courtney told him that attack from above needed elevated, not downward, fire.[127] Ellington gave up on being reminded that the other F.9/35 designs were single-engined aircraft, and "consequently" agreed to a midships turret.[128] The logic of this discussion is difficult to understand because the specification permitted one or two engines.

Air Staff Requirement F.9/35 was approved by Ellington[129] and circulated to industry in April 1935, with the full specification following a month later.[130] The Boulton Paul Defiant was ordered in 1938.[131]

6.3.4 Moveable Guns for Single-Seat Fighters

It is mentioned in chapter 5.3.2 that when the requirements for the new day and night fighter F.10/35 were discussed the question of traversing guns arose. This was another aspect of the RAF's search for a means of obtaining concentration of fire from fighters attacking in formation. It appears to have been first proposed in 1932 by Group Captain L.A. Pattison in his entry to the Novel Fighter competition, where he suggested that, "the pilot of a single-seater should be enabled to adjust the angle of his guns whilst in flight".[132] Squadron Leader G.A. Pidcock put forward a similar idea in his entry.[133]

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126 ibid., CAS to DCAS, 15.11.35
127 ibid., DCAS to CAS, 19.11.35
128 ibid., CAS to DCAS, 20.11.35
129 ibid., CAS to DCAS, 8.4.35
130 ibid., Air Staff Requirement (4A) circulated 18th April 1935 and Specification for "Two-seater Day and Night Fighter", issued 20th May 1935
131 ibid., DCAS to CAS, 22.1.38
132 2/1323, Part II, 1A
133 ibid., Part III, 2A

In 1934 AVM P.H. Playfair suggested "remote controlled moveable guns in single seaters",[134] and this possibility was included by Brooke-Popham in his "Notes on Design and Tactics of A.D.G.B. Fighters".[135] The Air Fighting Committee then proposed trials to investigate such "offset" guns to see if the flank fighters in a formation could attack without risk of collision.[136] The pilots will still have to take aim, and at the next meeting of the committee it was thought that the attacking formation should be limited to three aircraft.[137]

Then in January 1935, Verney (DTD) minuted Dowding (AMSR) that,

> Wing Commander Keith has brought forward a new scheme for formation fighting which necessitates traversing the wing mounted guns through an arc of about 50°. I have shewn the scheme tentatively to the D.C.A.S. who is very interested, as it is evident that it offers a means of greatly increased rate of fire and concentration without the necessity for mounting as many as 8 guns, which may present difficulties.

Verney suggested that some experiments should be made on this scheme.[138] He was told to show it to the CAS,[139] who pressed for it to be investigated.[140,141]

Keith's idea (which he does not mention in <u>I Hold My Aim</u>) was an elaboration on the use of offset guns. It was to enable the guns of a formation of fighters to be aimed continuously at a target during an approach on the "curve of pursuit". Keith went further in proposing that all the fighters in a formation attack should aim at one member of an enemy formation to increase the likelihood of a lethal

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134 16/305, 74A, Playfair to HQ ADGB, 14th April 1934, para.4
135 ibid., 78A, 23rd April 1934
136 PRO: AIR 5/1126, <u>Minutes of Air Fighting Committee Meetings 1-21</u>, Second Meeting, 12th November 1934, Item 11
137 ibid., Third Meeting, 1st March 1935, section 2
138 PRO: AIR 2/1575, <u>Traversing Gun Mounting for Wing Guns in Fighters</u>, DTD to AMSR, 7.1.35
139 ibid., DCAS to DTD, 11.1.35
140 2/2821, CAS to DCAS, 8.4.35
141 ibid., CAS to DCAS, 12.4.[35]

hit. This idea was based upon a false application of probability theory by Captain Hill, which was corrected by Pattison.[142] Nevertheless, Verney told the DCAS that despite their different views on probability theory, Hill and Pattison had no dispute over the value of traversing guns.[143]

Arrangements were made to conduct experiments by fitting guns which could be traversed in the horizontal plane to an experimental aircraft, the "Hendy Heck". This aircraft, built by the Parnell Aircraft Company,[144] was used for a number of experiments on wing-mounted machine guns.[145,146]

Meanwhile, fighter requirement F.10/35 (Hurricane and Spitfire), and its derivative specification F.37/35 (the cannon fighter), said that it was "contemplated that some or all these [their] guns should be mounted to permit of a degree of elevation and traverse with some form of control from the pilot's seat".[147,148] This astounding requirement was later deleted from the cannon fighter specification,[149] but experiments with moveable wing-mounted machine guns continued until the AOC-in-C Fighter Command (Dowding) decided in 1937 that the extra weight was not justified. Dowding, did, however, think that there might be some merit in guns which were moveable in the vertical plane - to permit no allowance shooting.[150] The DTD observed that this was impractical with wing-mounted guns,[151] but nevertheless no allowance shooting was re-examined by the Armaments branch.

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142 2/1575, 5B, Notes and Criticism of H.Q. Armament Group - A.F.C./4 "Curve of Pursuit Attack System for Aircraft with Off-Set Guns Mounted on the Wings."
143 ibid., DTD to DCAS, 24.1.35
144 Wixey, K.E., Parnell Aircraft since 1914, 1990, page 214
145 Keith, page 80
146 2/1575, DTD to DSD, 29.7.37
147 2/2821, 13B, Armament section
148 ibid., 43B, Armament section
149 ibid., letter to contractors, 4th April 1936
150 2/1575, AOC-in-C to Air Ministry, 1st July 1937
151 ibid., DTD to DSD, 29th July 1937

The elevation required to achieve no allowance shooting at the combat speeds expected in the late 1930s had greatly decreased from the 45 degrees of the biplane era,[152] and it was concluded that "For practical purposes the N.A. method at low angles of attack both in method of application and the results to be expected, blends into the stern chase long range method."[153]

Undeterred by (or unaware of) this conclusion and the DTD's advice on the impracticality of elevating wing-mounted guns, the first draft of specification F.18/37 (Typhoon and Tornado, discussed in chapter 9.2.1) stated that "The Air Staff are anxious that the guns should be adjustable in elevation, over the range required for no-allowance sighting, i.e. from 0° to 15° elevation, if this is possible."[154] This request was dropped from the requirements before they were finalised for circulation to industry.[155]

6.4 SUMMARY

The drive for increased firepower led to the specification in 1934-35 of single-seat fighters with eight machine guns or four 20mm cannon - far in advance of the armament specified by other air forces at the time. Nevertheless, the belief that bomber formations could defend themselves against attack by fixed gun fighters, however well armed, led to widespread support for multi-seat fighters on the assumption that only they offered hope of breaking up formations of bombers. But the end product of this line

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152 PRO: AIR 8/214, The Attack and Armouring of bombers, CAS to AOC-in-C, 2nd December 1937

153 2/1575 ibid., 27A, Notes by R.D.Arm. on Up-Set Guns and their Relation to "No Allowance" Methods, 19.10.37, para. 21

154 PRO: AIR 2/2833, Tornado and Typhoon. Single Seater Fighter - Specification F18/37. - Type Requirements, 4A, First Draft Air Staff Requirement for a High Speed Single Seat Fighter Landplane Specification F.18/37, para. 3

155 ibid., 20A, Appendix "B" to Specification F.18/37, 26.1.38

of development - the Defiant - was to be confronted by bombers escorted by single-seat fighters, and was outclassed by these as Dowding had predicted.

Although there is little evidence of how multi-seat fighters would have fared in their intended role of attacking unescorted formation of bombers, there is some experience of the plan to attack from a bomber formation's blind spot. Guy Gibson described how effective this could be when the bombers could not turn away. During the Norwegian campaign his squadron of Hampdens was attacked by Me 110s, and he wrote that these,

> had one gun which can fire sideways. Their mode of attack was to fly in formation with the Hampdens perhaps fifty yards out and slightly to the front, and pick off the outside man with their one gun aiming with a no deflection shot at the pilot. The bomber boys could do nothing about it; they just had to sit there and wait to be shot down. If they broke away they were immediately pounced on by three Messerschmitt 109s waiting in the background.[156]

Only four of the twelve Hampdens returned.

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156 Gibson, G., <u>Enemy Coast Ahead</u>, 1986 (first published 1946), page 64

7. BOMBERS TO ATTACK FRANCE

7.1 INTRODUCTION

In the early 1930s, up to the emergence of Germany as a threat to Britain, the Air Staff continued to call for bombers with characteristics suitable for a war with France. It took the distance to Paris as the criterion for the range of the day bombers which were to form its main striking force.

The development of these aircraft was much influenced by discussion at the Geneva Disarmament Conference of a limitation of the size of bombers, and for the same reason no replacement heavy night bomber was put in hand. When the Geneva conference broke up in 1934, a crash programme for a new night bomber was started, and for this too the requirements were initially based upon those of the 1920s.

A new factor was introduced into bomber requirements in the early 1930s in response to Japanese aggression in the Far East, and was given more prominence after the 1935 Abysinnian crisis. This was a requirement for a ferry range sufficient to reinforce the Middle and Far East. Then, with the recognition of Germany as the potential enemy in Europe, came demands for increased operational range, speed and armament. It was primarily these factors that led to much larger bombers than had previously been sought by the RAF, as will be shown in chapters 8 and 9.

This chapter deals with the earlier period when France was the nominal enemy. It examines the thinking behind the initial development of all but one of the bombers with which the RAF entered the Second World War - the Battle, Hampden, Wellington and Whitley - the Blenheim is the exception. The operational requirements which led to these aircraft emerged largely as part of the process of seeking replacements for aircraft in service.

1934 saw the first moves away from separate day and night bomber classes towards the long desired dual-role bomber. The initiative for this came from Ludlow-Hewitt, paralleling his efforts to rationalise RAF fighter development. Following a meeting in March 1934 to consider the requirements for a new night bomber, Ludlow-Hewitt decided to give effect to the opinion of the meeting that the night bomber should be capable of work by day, and similarly that day bombers should be available for night work. He said that the performance of the aircraft being planned to replace the night and day bombers then in service should "justify the hope that this increase of flexibility in the use of our bombing squadrons may prove to be practicable". There was strong support from the AOC-in-C ADGB (Air Marshal Sir Robert Brooke-Popham), who regarded the hard and fast division between day and night bombers as a temporary stop gap before it was possible to carry out Trenchard's decision of 1923 that the majority of bomber squadrons should be capable of operation by day and night.[1]

Ludlow-Hewitt proposed that in future night bombers should be renamed "heavy bombers", day bombers should be called either "single-engine medium bombers" or "multiple-engine medium bombers", and that replacements of the Hart type should be renamed "light bombers".[2] This at first led to little more than giving new names, and equipment, to requirements which had been drawn up for distinct day bombers and night bombers. It was not until 1936 that the long-desired dual role for bombers was specified from the beginning.

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1 PRO: AIR 2/729 , Heavy Bomber Specification B3/34. Type Requirements, 13A, 18.6.34

2 ibid., DCAS to CAS, 13.3.34

Section 7.2 discusses the operational requirements for day bombers. These first continued the dialogue on the relative merits of fast single-engined bombers - which relied primarily upon evasion for their defence - and slower twin-engined bombers with greater gun defence. Plans to develop the latter started first with the Sidestrand replacement project, B.9/32. Their fulfilment was delayed by attempts to meet a weight limitation, but eventually the Handley Page Hampden and Vickers Wellington emerged from this requirement.

When a replacement for the Hart high-performance (light) bomber was considered, the desire to compare this single-engined project with the Sidestrand replacement led to the specification of a bomb load twice that of the Hart. In consequence this requirement drifted into that for a single-engined medium bomber. The unhappy outcome was the Fairey Battle, with neither high performance nor adequate gun defence. The light bomber class was then put back on course with a true Hart replacement project, but designs to this requirement did not lead to an aircraft which entered service. The Air Staff came to the view that light bombers were unsuitable for a war with Germany.

The limitation on bomber weight discussed at Geneva was likely to be most restrictive on the design of heavy night bombers, and in 1933 extreme measures were briefly considered to overcome this problem. When a new night bomber was sought urgently in 1934, attempts to involve the aircraft industry in drawing up the specification and hastening development led to many problems and much dissatisfaction with the product. These matters are discussed in section 7.3. They led on to plans for an "Americanised" heavy bomber, which can be seen as the transition in operational requirements from those of the 1920s to those appropriate for war with Germany.

7.2 DAY BOMBERS

In chapter 4 it has been shown that during the 1920s the RAF's concept of day bombers had become divided into two classes, high performance and medium performance. Through much of the 1930s the prime exponent of the high-performance day bomber class in service was the Hawker Hart and its derivatives. At the end of 1936 these equipped twenty-five squadrons.[3] By contrast, until 1935, the medium performance class of day bomber was represented by the one squadron of twin-engined Sidestrands which had been formed in 1929. This balance was to change dramatically when the bombers which followed from the events discussed in this section came into service in the late 1930s.

The single- *versus* twin-engined day bomber issue came to the forefront in October 1930. The AMSR's department put forward a project for a "High Speed 1000 lb. Bomber", "Twin H[alford]. or F[alcon]. engines, for Home Defence work. To carry twice bomb load of present types and great [speed] or defence."[4] Maund (FO1) advised the DCAS that if this was intended as a Hart replacement, the Air Staff neither needed nor had asked for such a project. If, on the other hand, the AMSR was seeking to perpetuate the Sidestrand class - despite what he said were, "its admitted disabilities of strategic immobility", Maund thought that the proposed aircraft was unduly large - "2 H engines to drop 1,000 lb. bombs is rather like giving a battle cruiser 4" guns as primary armament!".[5]

It is evident from later correspondence that, perhaps in response to Maund's criticism of the size of his project, the AMSR (Dowding) suggested that the ambiguous "High Speed 1000 lb. Bomber" might be met by a single-engined aircraft powered by a new Rolls-Royce engine. This was

[3] Moyes, P.J.R., <u>Bomber Squadrons of the RAF and their Aircraft</u>, 1964, Appendix 7

[4] 20/68, page 91, Air Estimates 1931

[5] ibid., page 101 of note by F01, 6.10.30

the Griffon, which Dowding said was being developed from the company's Schneider Trophy racing engines.[6]

An unfortunate consequence of this interchange was that the genuine issue of evasion versus defence (or high or medium performance) for day bombers became obscured by arguments over the relative merits of single- or twin-engined bombers.

The ADGB Command had been instructed to make comparative trials of the single-engined Hart and twin-engined Sidestrand, and, in Maund's words, had concluded that "the Hart is unquestionably the better form of day bomber".[7] Thus in February 1931 the DCAS (Burnett) advised the CAS, Sir John Salmond, that a new twin-engined bomber should not be developed, at least for the time being. He argued that in view of ten-year rule the most urgent requirement was to have bombers which were suitable for reinforcing overseas commands. (This was at the time of the start of Japanese aggression in the Far East). Burnett said that a twin-engined aircraft was not suitable for reinforcing purposes, "because of shipping difficulties, and the time required to erect it",[8] i.e., after it had been dismantled for shipping - single-engined aircraft were much easier to transport by sea.

However, Plans branch of the Air Staff saw that the ADGB's preference for single-engined bombers was based upon comparison between the new Hart and the older Sidestrand. Whereas Boulton & Paul, manufacturers of the Sidestrand, claimed that an up-to-date version would be faster than the Hart. Plans concluded that a twin-engined day bomber would thus be better in every respect, even to the extent of being capable of day and night operations and of

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[6] PRO: AIR 2/2745, Medium Bomber - Type Requirements Specification P27/32, DCAS to CAS, 21.4.32

[7] 20/84, FO1 to DCAS, 7.3.31, attached paper Comments by F.O.1 on S.E. versus T.E. Bombers, 10.2.31

[8] ibid., DCAS to CAS, 21.2.31,

torpedo dropping.[9] They would have to wait until 1936 for these attributes to be written into Air Staff requirements.

In March 1931, Maund reviewed all the papers on single- versus twin-engined bombers. In his comparison of the Hart with the Sidestrand he assumed that the Sidestrand could carry twice the bomb load (1,000 lbs) over the same range as the Hart[10] - a matter on which there seems to have been some doubt. It is noted in chapter 4.2.2.1 that in 1928 the Hart and Sidestrand were credited with the same bomb load (500 lb) at the same range, and this was confirmed in 1933.[11] Clearly to credit the Sidestrand with twice the bomb load of the Hart favoured the former. Even so, after taking account of total expenditure and manpower, and the likelihood of success in delivering the same bomb tonnage - a mode of analysis which came into great prominence in later years - he concluded that there was overwhelming evidence in favour of the Hart.

Nevertheless, like Plans, Maund was conscious that comparisons were being made between the Hart of good recent design and the older Sidestrand, and was not prepared to rule out future twin-engined day bombers. He said that he would cast Hart replacement requirements deliberately to embrace both single- and twin-engined designs, and outlined a set operational requirements for a twin-engined type to compete with the Hart. These included provision for replaceable auxiliary fuel tanks to give strategic mobility through a ferry range of 1,250 miles.[12] (This was to be increased in 1934 to 1,500 miles

[9] 9/37, Folio 19, Note by Plans, 25.2.31
[10] 20/84, FO1 to DCAS, 7.3.31, Table I
[11] ibid., DCAS to DDOI, 20.4.33
[12] ibid., Table II of FO1 to DCAS, 7.3.31

"to cover the distance to Gibraltar"[13] - which did not then have an RAF airfield.[14,15])

Faced with this somewhat confusing advice, the CAS decided to take the common sense course of first ordering a multi-engined replacement for the obsolete Sidestrand. But Burnett and Maund persisted in seeing this as a twin-engined Hart replacement - with unfortunate consequences.

7.2.1 Sidestrand Replacement: B.9/32 (Wellington and Hampden)

In response to Salmond's instruction, Burnett submitted proposed "Multi-Engined Day Bomber. Operational Requirements" in July 1931[16,17] - these were much as Maund had suggested. They included a range of 600 miles at full throttle, a bomb load of 1 lb per hp, and provision to carry extra fuel in lieu of half the normal bomb load - a step towards providing the means to mount continuous attacks on distant targets. The day bomber was to have a maximum speed of not less than 190 mph at 15,000 ft and a landing speed of 60 mph. Although Burnett emphasised the importance of defensive power, he proposed but three single gun stations, two of which were to be aft of the wings. All were to be protected from the slipstream. It was later decided that if an unrestricted field of fire aft was available - as from a tail turret - one aft gun station would suffice.[18]

Salmond accepted these requirements, but feared that if designers were given complete freedom over the dimensions

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13 PRO: AIR 2/2744, Multi-Engined Day Bomber Type Requirements - Specn. B.9/32, OR to RDA3, 15.8.34

14 PRO: AIR 2/2718, Bomber Squadrons Policy Future of the Light Bomber, DCAS to CAS, 18.1.36

15 Fairbairn, T., Action Stations Overseas, 1991, page 71

16 2/2744, DCAS to CAS, 19.7.31

17 ibid., 1A,

18 ibid., CAS to AMSR, 7.9.32

of the aircraft, then "these machines may become so large that we cannot get them into any of our sheds; e.g., the bomber transport machine will not fit into any shed we have at home or abroad." (Reference has been made to this point re C.16/28 in chapter 4.4.3.) He asked that this matter should be investigated and a limit on size laid down.[19] This was the first time such an issue had arisen, and although it did not have a significant impact on the aircraft which resulted from the operational requirement under discussion, many writers believe it had an important influence on the design of some larger bombers which appeared later, a matter which is discussed in chapter 8.

The AMSR's department examined Burnett's operational requirement, and in September 1931 advised that it, "asks for rather more than we can expect to get". Dowding pointed out that the Air Staff were specifying a bomber with the same performance as the fighter F.7/30, yet with a range of 600 miles at full speed carrying 1,000 lbs of bombs (with two 525 hp engines[20]). Little wonder that the RAF was concerned about its ability to defend London if it believed that even twin-engined day bombers could have the same performance as its fighters.

Dowding told Burnett that the best combination appeared to be a maximum speed of 185 mph at 11,000 ft, and that even this would need a landing speed of 65 mph. He said that this estimate was based upon "the best existing constructional practice", but added that he knew of a Siddeley's design for a twin-engined aircraft with a retractable undercarriage. Dowding admitted that, "it is possible that other firms may have new ideas which would increase the performance beyond that which we consider to be attainable at the present time".[21]

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19 ibid., CAS to DCAS, 21.7.31
20 ibid., 4A, Liptrot, 24.9.31
21 ibid., AMSR to DCAS, 29.9.31

On seeing Dowding's views, Maund explained to Burnett that, whilst contractors tended to be optimistic, "D.T.D.'s experts estimate on current practice, and do not allow for future progress. With his responsibilities, A.M.S.R. no doubt prefers to make conservative estimates to us."[22] Burnett was not happy with this policy, and suggested to Dowding that "we should legislate in our specifications for as much progress as possible, without damping the ardour of contractors". He too referred to a current design - a Boulton & Paul private venture - which he said matched his operational requirements, except for landing speed.

Burnett insisted that the purpose of the new requirement was to test a twin-engined bomber, and as it would be a later design than the Hart, but with the same bomb load per horsepower, it was reasonable to expect a better performance. To accelerate action he said that he would accept a landing speed of "not more than 65 mph, preferably less".[23]

A new draft specification (B.9/32)[24] was put in hand to take account of the higher landing speed and of Salmond's comment on hangar size.[25] It also took account of the new scheme for defining range and speed which had been introduced early in 1932, as discussed in chapter 3.4.5. The DTD explained that,

> the specified range (...) is now 720 miles, and speed (...) is 170 m.p.h., both at Normal R.P.M. These correspond to the 600 miles and 190 m.p.h. at Maximum R.P.M. originally called for by the Air Staff.[26]

The CAS was later to decree that the maximum speed should continue to be quoted at maximum rpm , i.e., full

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[22] 20/84, FO1 to DCAS, 5.10.31
[23] 2/2744, DCAS to AMSR, 14.10.31
[24] ibid., 17A
[25] ibid., AMSR to DTD, 16.10.31
[26] ibid., DTD to DCAS and AMSR, 22.8.32

throttle.[27] Note that in the quote above "Maximum" clearly means "full throttle", for that was associated with 190 mph in the first draft operational requirements.

There is no indication that the change in range consequent upon the new definition was seen to have any operational significance. Indeed, in the requirements for a single-engined Hart replacement (to be discussed below), Burnett specified a range of 600 miles under the new definition, and made a point of telling the CAS that, "The range requirement (...) will put Paris within range of our most distant Home Defence day bomber aerodromes."[28] Since the Air Staff's declared aim was to compare the twin-engined B.9/32 with a single-engined Hart replacement the extra 120 miles which was obtained "accidentally" for the former was unnecessary. It might have been exchanged for an increase in bomb load or maximum speed, a reduced landing speed, or for a smaller and cheaper aircraft.

As discussed in chapter 3.4.5, as the 1930s progressed the cruising speed and range of bombers were progressively redefined to approach realistic operational practice. But in 1932-33 the failure to follow up the consequences of the change in definition of range was to have an adverse effect on the Hart replacement project.

With regard to the question of a limitation on span, it is notable that, contrary to the Air Ministry's supposed predilection for biplanes, Liptrot was instructed to calculate the span required to meet B.9/32 as for a monoplane.[29] (This was in October 1931 - the month in which fighter specification F.7/30 was issued.)

It was found that the RAF's permanent hangars were large enough for the proposed bomber, and the size of Expeditionary Force hangars was investigated. A File Note

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27 ibid., CAS to AMSR, 7.9.32

28 2/2745, DCAS to CAS, 21.4.32

29 2/2744, DTD to RDA3, 20.10.31

gives details of a transportable "Bessnoneau" hangar (of 1914-18 war vintage[30]), which had a width of 63 feet and a length of nearly 80 feet.[31] It is not clear whether these dimensions led to the inclusion of a limit on span of 70 feet in the specification,[32] or whether this came from Liptrot's calculations.[33] Whatever the reason, the Air Staff suggested that folding wings should be allowed to overcome the limitation on span,[34] and this option was included in the specification.

A much more serious limitation on the design of aircraft to meet specification B.9/32 arose from the Geneva Disarmament Conference. Under discussion was a proposal to limit the empty (or tare) weight of bombers to three metric tons. The Air Ministry feared that specification B.9/32 could not be met at this weight, and Dowding suggested delaying its issue until the situation became clearer, for he wished to protect industry from producing a type for which there might be no market.[35] Salmond's reaction was that they must not let the disarmament talks delay technical progress, and he proposed to insert into the specification a tare weight limit of 6,500 lbs. He was prepared to accept a crew of three if it were possible to arrange for a single gun to have an unrestricted field of fire aft.[36] The DTD (Cave) then suggested that the weight limit should be reduced to 6,300 lbs so as to allow for the inevitable increase in weight during development.[37] Salmond agreed, and specification B.9/32 with this weight limit was issued on 17th September 1932.[38,39]

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30 Barker, R., The Royal Flying Corps in France - from Mons to the Somme, 1994, page 204
31 2/2744, 12A
32 ibid., 13A
33 ibid., 4A
34 ibid., 14A
35 ibid., AMSR to DCAS, 23.8.32
36 ibid., CAS to AMSR, 7.9.32
37 ibid., DTD to AMSR, 13.9.32
38 ibid., CAS, 17.9.32
39 ibid., 31A, Specification No. B.9/32. Twin-engined Day Bombing Aircraft, issued 17th September 1932

In December 1932 Liptrot reported that several of the firms which were interested in tendering to B.9/32 were concerned about the weight limit. He estimated that to keep within 6,300 lbs the maximum speed would be no more than 175 mph. Alternatively, to keep 190 mph, the bomb load would have to be reduced to 500 lbs, and the range to 560 miles. Liptrot advised that, "The only other way of getting the low tare weight is by falsifying figures, i.e. by considering what are really tare weight items as removable." He suggested that the gun mountings and automatic controls might be left out. Even then it was likely that only biplane designs would meet the limit of 6,300 lbs.[40]

On hearing of this, Maund (FO1) pointed out that Salmond's initial limit had been 6,670 lbs[41], and that he had reduced this to 6,500 lbs to allow for development. Cave had then reduced it to 6,300 lbs for the same reason![42] Salmond had of course agreed to the second reduction, but by now the Ministry was becoming very concerned about the impact of the proposed weight limit, and the specification was corrected back to 6,500 lbs.[43] In addition, firms were told that they could leave out the automatic controls when calculating the tare weight.[44]

Later, when the Ministry had selected the monoplanes tendered by Vickers and Handley Page, these could not meet the weight limit. Vickers were told that they could also leave out the water in the engine cooling system. Handley Page, who planned to use air-cooled engines, were told that if they exceeded 6,500 lbs by no more than 100 lbs their tender would not be rejected.[45] These machinations

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40 ibid., 33A, RDA3 to DTD, 5.12.32
41 3 metric tonnes actually equals 6,614 lbs
42 2/2744, FO1 to DCAS, 13.12.32
43 ibid., 40A, Corrigenda to Specification B.9/32, 20th December 1932
44 ibid., 39A, RDA3 (for DTD) to contractors, 20th December 1932
45 ibid., DTD to AMSR, 10.2.34

underline the problems faced by the Air Ministry during the disarmament talks.

A new aspect of the weight limit problem was raised by Wing Commander Williams, (who succeeded Maund as head of Flying Operations 1 in January 1933). He saw that the proposed limit, which so far had been considered only in respect of the new day bomber, would also have the effect of rendering the RAF's existing heavy night bombers illegal. This led him to suggest a remarkable version of the long-desired dual-role bomber.[46]

Williams first compared current Air Staff requirements for day bombers and night bombers, which he put as,

	bomb load lbs	range miles	landing speed mph
Day bomber			
B.9/32 normal	1,000	720	65
or (i)	500	920	65
or (ii)	1,500	500	65
Night Bomber	1,500	920	55

Williams saw that to graft the night bomber requirements onto the day bomber would lead to an aircraft suitable for neither mode of operation. He proposed another solution, namely to build the day bomber with a fuselage suitable to take alternative wings to meet the night bomber requirement (primarily to meet the lower landing speed). He had been advised by the technical branches that this was a practical proposition, with a loss of speed of the day bomber of no more than 5 mph.

Williams argued that in this way the RAF could get a new night bomber which met the feared restriction on weight within three years, as opposed to seven years if they started from scratch. He claimed that the tare weight

46 ibid., 42A, Sidestrand Replacement. Question of Alternative Wings, FO1 to CAS, 14.3.33

limit in the specification of 6,300 lbs left 314 lbs in hand for modifications (such as his) when compared with three metric tons. Clearly Williams had not caught up with the corrigendum to the specification which had raised the weight limit for B.9/32 to 6,500 lbs.

No action was taken on Williams' scheme, but when the question of the award of contracts for B.9/32 came up in June 1933 he raised it again - "Quite apart from any question of disarmament".

Williams suggested that there would be considerable advantages in having an aircraft which could be converted from day to night, and reiterated Trenchard's argument for a dual-role bomber (chapter 2.3.1). He said that,

> it would enable us to adjust the proportion of bombing effort with varying lengths of day and night in different countries and at different seasons of the year, or even with changing phases of operations.[47]

This remarkable proposal brought forth comments from other branches of the Air Staff. Those of Air Commodore R.E.C. Peirse, who had been DDOI (i.e., deputy head of the Air Staff) throughout the gestation of B.9/32, are an example of the lack of consultation on the formulation of operational requirements - it will be remembered that FO1 reported directly to the DCAS. Peirse questioned the very basis of B.9/32. He wrote that, "I think we are on the wrong tack in going for a multi-engined day bomber of the size of either the Vickers or the Handley Page", but said that if that was the policy then any loss of performance should not be accepted.[48] On the other hand Plans branch (Squadron Leader G.E. Gibbs) thought that on balance Williams' scheme was a good idea.[49]

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[47] ibid., 42A, FO1 to CAS, 2.7.33
[48] ibid., 42A, DDOI to DCAS, 7.7.33
[49] ibid., 42A, Plans to DCAS, 6.7.33

The DCAS (Ludlow-Hewitt) gave the official Air Staff opinion to Ellington. He did not agree with Williams' scheme. He cited loss of performance for the day bomber, the danger of meeting neither role, and the expense of stocks of two sets of wings.[50] Ellington settled the matter by telling Dowding that alternative wings were not required.[51]

In 1934 the Disarmament Conference collapsed and Germany had became recognised as a potential enemy. Dowding asked if in view of the changed political situation the weight limit was to be retained,[52] and on 7th June 1934 Ellington agreed to remove it.[53] In fact consideration of a new night bomber, which would inevitably exceed the three metric ton limit, had begun earlier in 1934. It is discussed in section 7.3.

The contractors designing to day bomber specification B.9/32 asked if bigger engines could be fitted now that the weight limit had been removed. They hoped to raise the speed to at least 230 mph.[54] Dowding's comment to Ludlow-Hewitt on this issue summed up all that had gone before. He wrote "I have agreed to the proposals to fit more powerful engines [to B.9/32]. You will realise the previous weight restriction (now removed) imposed a severe handicap on designers."[55]

In February 1935 an important step was taken towards Ludlow-Hewitt's aim to have all aircraft capable of day and night operation. Although intended for a day bomber, specification B.9/32 had required emergency night-flying equipment for take-off and landing at dawn or dusk.[56] It

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50 ibid., 42A, DCAS to CAS, 14.7.33
51 ibid., CAS to AMSR, 15.7.[33]
52 ibid., AMSR to CAS, 24.5.34
53 ibid., DCAS to AMSR, 7.6.34
54 ibid., DTD to AMSR, 18.8.34
55 ibid., AMSR to DCAS, 21.8.34
56 ibid., 31A

was established that this could be augmented to allow full night flying for a weight increase of but 10 lbs.[57]

The aircraft ordered to specification B.9/32 became known as the Vickers Wellington and Handley Page Hampden. Their development had been much delayed by attempts to meet the weight limit and by redesign when the limit was lifted. The first flight of each did not take place until 1936.

There can be little doubt that had their development not been retarded the specification would have led to bombers superior to any others conceived in the early 1930s. As it was, the Hampden was amongst the fastest bombers in the world when it came into service in 1938,[58] and improved versions of the Wellington served usefully throughout the Second World War. On the other hand, had the basic designs been settled in 1932-33 as intended, they might have been wholly obsolete by 1939. Indeed, as early as November 1934 both the CAS and DCAS believed that the designs to B.9/32 were then obsolete and that a new specification was needed.[59] Ludlow-Hewitt later admitted that this view was an overstatement, but nevertheless suggested that, "the medium bomber specifications having been made out before recent advances in speed were quite so apparent as they are now", early provision should be made for an up-to-date medium bomber.[60] In October 1935 a new medium bomber was included in the Experimental Aircraft Programme for 1936 - it was P.13/36 - from which came the Halifax and the Manchester/Lancaster.

7.2.2 <u>Hart Replacements</u>: P.27/32 (Battle) and P.4/34

The Hawker Hart was the epitome of the so-called high performance day bomber class. Maund described it as "the

57 ibid., RDA4 to OR, 13.2.35
58 Thetford, page 313
59 2/716, DCAS to AMSR, 26.11.34
60 ibid., DCAS to AMSR, 5.12.34

most promising machine the service has had since the war".[61] Although it had a small bomb load and a radius of action barely sufficient to attack Paris, when it entered service it was as fast or faster than contemporary RAF fighters. However, as has been shown earlier in this chapter, when the question of a replacement arose, this became caught up in the debate on single- *versus* twin-engined bombers. Salmond's decision to first develop a twin-engined Sidestrand replacement with bomb load of 1,000 lbs meant that if comparability was to be achieved the Hart replacement would need to match this.

In Dowding's advice that such an aircraft might be based on the Rolls Royce Griffon engine, he seems to have taken to heart Burnett's plea that they should not dampen the ardour of contractors, for this engine was yet to be developed. Burnett was encouraged to believe that the Griffon would allow an increase in both bomb load and speed as compared with the Hart.[62] His "Proposed Operational Requirements" of April 1932 asked for a bomb load of 1,000 lbs, a range of 600 miles (at maximum permissible continuous rpm) and a top speed of 195 mph. An armament of one fixed and one rear machine-gun was specified.[63] Burnett's remark to the CAS on the range requirement has been discussed above. He also noted that the speed requirement was 15 mph above that of the original Hart (which he said was not met), and that this placed the proposed aircraft on a competitive basis with the Sidestrand replacement then under discussion.[64]

Dowding saw the similarity with the Sidestrand replacement project in a different light. His staff calculated that the new project would be twice the weight of the Hart and have a top speed of only 185 mph,[65] and Dowding saw this

61 20/68, page 102, note by FO1, 6.10.30
62 2/2745, DCAS to CAS, 21.4.32
63 ibid., 1A, undated, c. April 1932
64 ibid., DCAS to CAS, 21.4.32
65 ibid., DTD to AMSR, 21.732

as simply duplicating the Sidestrand replacement. He suggested that the requirements should be reconsidered.[66]

Burnett's response was to remind him that, "The requirements were drawn expressly to be comparable with those of the Sidestrand replacement, so that we can assess the relative values of the two classes by contemporary types of single-engined and twin-engined aircraft." Burnett wished to proceed with the specification.[67] It was put in hand in together with the development of the supercharged Griffon.[68] Specification No. P.27/32 for a "Single-engined Day Bombing Aircraft" was issued in April 1933.[69]

It is clear that by pursuing the single- *versus* twin-engine issue the original intention to develop a new type in the high-performance day bomber class had become lost. This was recognised by Ludlow-Hewitt when he had replaced Burnett as DCAS. In July 1933 he put to the CAS (now Ellington) and Dowding, that in regard to Burnett's Hart replacement requirement,

> This specification will produce an aircraft which will certainly not fulfil the need for a light high performance day bomber. It is questionable whether it will meet any particular requirement.

Ludlow-Hewitt believed that a small high-performance day bomber was needed, and recommended producing a new specification which would be more like the Hart with a bomb load of 500 lbs and a range of 600 miles.

To avoid the odium of cancelling the existing Hart replacement specification (P.27/32) after it had gone to contractors, Ludlow-Hewitt suggested increasing the range to 720 miles and then testing it against the concurrent

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66 ibid., AMSR to DCAS, 23.7.32
67 ibid., DCAS to AMSR, 2.8.32
68 ibid., DTD to ADRD, 10.8.32
69 ibid., 19A

Sidestrand replacement, B.9/32.[70] It seems that with changes in Air Staff personnel it was overlooked that 720 miles was called for in B.9/32 only because of a change in the definition of range - the original operational requirement had asked for 600 miles. Nevertheless, despite his earlier doubts - and his continuity of appointment - Dowding agreed with Ludlow-Hewitt's proposal. His reason was that without the P.27/32 there was little prospect of making use of the Griffon engine - an odd reason for developing a new aircraft. Dowding also agreed that a new small day bomber should be included in the following year's experimental programme.[71]

Thus P.27/32, intended as a replacement for the Hart high-performance (or light) bomber, became a single-engined medium bomber. Moreover, not only was the operational range increased over that first intended, but the B.9/32's ferry range requirement was added to the specification.[72]

Development of a single-engined medium bomber was perhaps a not unreasonable experiment at the time if an engine of the necessary power became available. It offered a fall-back position should the twin-engined designs to B.9/32 become unlawful.[73] But the Griffon engine did not materialise until many years later. In consequence the Fairey Battle to P.27/32 was fitted with the less powerful Rolls Royce Merlin and was under-powered.[74] Indeed in January 1939 Ludlow-Hewitt, then AOC-in-C Bomber Command, asked permission to restrict its penetration of hostile air space because of its slow speed and weak armament[75] - but by then a large number had been ordered in the cause of parity with the expanding German Air Force.[76]

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[70] ibid. DCAS to CAS (through AMSR), 21.7.33
[71] ibid., AMSR to CAS/DCAS, 31.7.33
[72] ibid., 28A, Corrigenda No. 1, 24.10.33
[73] ibid., DTD to AMSR, 16.3.34
[74] Thetford, page 273
[75] PRO: AIR 2/2620, Fairey Battle Bomber Aircraft to Specn P.27/32 Type Requirements, AOC-in-C to Air Ministry, 14th January 1939
[76] Postan, pages 11 and 489

7.2.2.1 A True Hart Replacement

Ludlow-Hewitt's and Dowding's plan for a direct replacement for the Hart was put to a meeting of the 'Operational Requirements Committee' in March 1934. Surprisingly, after what had gone before, the draft Air Staff Requirement proposed that designers should be given a free hand to choose one or two engines. The aircraft was said to be primarily for a European war, to be capable of dive bombing, and to rely on speed for evasion of hostile fighters. A bomb load of 500 lbs was to be carried over a range of 600 miles at normal rpm.[77]

Before the meeting the DDOI (Plans) (Harris) advised that a range of 600 miles would not be adequate in six to seven years time. He suggested that 800 miles should be required. Harris was forthright on the proposed limitation on span, writing that "arbitrary limitations unconnected with operational efficiency tend only to produce freaks like the London taxi-cabs & H.M.S. Nelson."[78] It was decided to proceed with a range of 600 miles but the limit on span was dropped .

When Ludlow-Hewitt reported the meeting's decisions on the new Hart replacement to Ellington, the CAS's reaction was to ask that the specification should indicate a preference for a twin-engined aircraft.[79] Ellington had in mind that a twin-engined aircraft could have a moveable front gun, and a better view and bomb aiming position than would be possible with a single-engined aircraft.[80] Inevitably, the technical branches advised that to meet the requirements a twin-engined aircraft would be considerably

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[77] PRO: AIR 2/728, High Performance Day Bomber (500 lbs. bomb load) Type Requirements, 1A

[78] ibid., Plans to FO1, 6.3.34

[79] ibid., CAS to DCAS, 16.3.34

[80] ibid., CAS to DCAS, 25.6.34

larger that a single-engined aircraft, and slower.[81,82] As regards Ellington's request for a moveable front gun, Ludlow-Hewitt explained that a fast day bomber would only use its front gun against an enemy two-seater fighter that took up position ahead of it, and that this was unlikely to be possible.[83] This was a surprising comment, since to exploit this form of fighter attack was the very reason that the RAF itself had re-started the development of two-seat fighters in 1930, as discussed in chapter 4.4.3.

Ellington reluctantly accepted a single-engined aircraft, but said that he would see what came of the twin-engined fighters which were under development "as a result of our efforts last year."[84] He was referring to the two multi-seat fighters, F.5/33 and F.22/33, which have been discussed in chapter 6. Both were twin-engined with moveable front guns and, as has been shown, both were to be discarded because of their low performance.

"Specification No. P.4/34. Light Day Bomber" was issued on the 12th November 1934,[85] and it appears that no lesson had been learnt from the P.27/32 saga. For when Ellington visited Faireys in January 1935, the company told him that the specification called for a bomb load of 1,000 lbs as an overload condition, and that to meet this they would have to increase the structure weight, which would reduce the performance. Ellington observed that, "In fact, the machine would come back again to the single-engined medium bomber."[86] Ludlow-Hewitt firmly advised that only a 500 lb bomb load should be required.[87]

The bomb load and range of P.4/34 thus finally reverted to that of the Hart concept of a light high-performance day

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[81] 20/84, RDA3 to AD/RDA and DTD, 11.5.34
[82] 2/728, DTD to AMSR, 14.6.34
[83] ibid., DCAS to CAS, 22.6.34
[84] ibid., CAS to DCAS, 25.6.34
[85] ibid., Appendix 27A
[86] ibid., CAS to DCAS, 4.1.35
[87] ibid., DCAS to CAS, 8.1.35

bomber. But this concept was now in doubt, and there were no production orders for either the Fairey or Hawker designs to P.4/34 as a light bomber.[88]

7.2.3 Demise of the Light Bomber

Towards the end of 1935 Ellington began to doubt the usefulness of light bombers in a war with Germany. He called for a review of bomber policy which took account not only of tactical effectiveness, but also of production and financial aspects.[89] This was another step towards a policy of optimising the RAF's bomber force to obtain the maximum bomb lift for a given cost.

In his response[90] to Ellington's request, the DCAS (now Courtney) noted that in the past light bombers had been developed because they were cheap, easy to pack for overseas, and their small bomb load and range was offset by a very high performance. Courtney then criticised such two-seat bombers in a way which paralleled the case against single-seat fighters which has been discussed in chapter 6. He said that the RAF had never solved the problem of the gunner/bomb aimer in two-seat bombers. The gunner could not use his gun and aim the bombs at same time, and the pilot could not fly the aircraft and operate the bomb sight.

In fact it was known that the bomb aiming position in single-engined two-seaters was so cramped that after using it for any length of time the gunner was not fit to use his gun afterwards.[91] Considering that the RAF had operated two-seat bombers for over fifteen years, this, and Courtney's comments, underline the point made in

[88] The Hawker Henley became a target tug and the Fairey evolved into the Fulmar naval fighter.

[89] PRO: AIR 2/2718, Bomber Squadrons Policy Future of the Light Bomber, CAS to DCAS, 8.11.35

[90] ibid., DCAS to CAS, 18.1.36

[91] PRO: AIR 2/956, Bombing Committee - Minutes of Meetings, 2nd Meeting, 30th May 1934

chapter 2 that the defence of bombers had not been taken seriously.

The Air Staff also at last recognised that whereas a formation of bombers each armed with one or two rear guns might have defended itself against attack from two-gun fighters, it would not be able to do so against eight-gun fighters. But to increase the light bomber's fire power would need a twin-engined aircraft[92] - and hence go down the route towards a medium bomber.

This was indeed the route which the Air Staff wished to follow. Courtney cited the performance of the Bristol Blenheim (derived from a Bristol civil aircraft and not in response to an Air Staff Requirement) as an example of the impact of recent developments in aviation. The Blenheim had a performance which matched that specified in P.3/34 and with double the bomb load - an indication that a medium bomber could be as fast as a light bomber, and could have better defensive armament. This is contrary to Smith's claim in respect of the rejection of light bombers, that "Speed was therefore to be sacrificed for warload and defensive armament."[93] It will be seen in chapters 8 and 9 that in fact there was no diminution in the pressure for speed.

Courtney proposed that a bomb load of 1,000 lbs coupled with a range of 1,000 miles should be the minimum to be considered. Despite the experience of P.27/32, he saw this as being met by a single-engined bomber, with 2,000 lbs and 2,000 miles from a twin, and a still higher load and range from four engines. He told the CAS that proposals on these lines would be in the 1936 Experimental Aircraft Programme. Their fate is discussed in chapter 8.

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[92] 2/2718, 1A, The Defence of Light Bomber Aircraft, OR2, 15.1.36
[93] Smith, M., page 235

Harris stressed the importance of range, as he had unsuccessfully when bomber requirements P.27/32 and P.4/34 were under discussion. He argued that in a German or Indo-Russian war the RAF would need to penetrate further than the enemy to reach comparably vulnerable targets. Harris countered the thought that the obverse of this argument was that an enemy would concentrate on fast light bombers, long feared by the RAF, by claiming that Germany had a high proportion of heavy bombers in recognition that if there was an international agreement on numbers of bombers, to have a large number of light bomber squadrons would be a disadvantage.

Harris took up Ellington's reference to overall economics. He suggested that an analysis in terms of striking power and cost, which led to the conclusion that light bombers were inefficient, might also lead to the disappearance of medium bombers. He visualised that a "most economical" size of bomber might evolve - into which all categories would merge.[94] This line of thought was to be followed in the studies of an 'Ideal Bomber' which were started in 1937, and are discussed in chapter 9.

The CAS accepted the views of the Air Staff and agreed to the gradual elimination of the light bomber.[95] At no time in this review of bomber policy was there the suggestion of a change in bombing policy.

7.3 HEAVY BOMBERS

The preceding sections of this chapter have discussed the operational requirements for day bombers which were appropriate for war against France. This consideration set the required range, as it had done since 1923. During those years it had been customary to seek a longer range

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[94] 2/2718, Appendix 2A, Plans to DCAS, 16.1.36
[95] ibid., CAS to DCAS, 29.1.36

for heavy night bombers as discussed in chapter 4. In 1934 Germany began to be seen as the realistic potential enemy, and by 1936 the requirements for medium and heavy bombers took this fully into account - by then both types were seen as capable of day and night operation. The series of heavy bomber requirements which are discussed in this section began early in 1934 and continued into 1935. They mark the transition between taking France as the potential enemy and seeking the performance required to attack Berlin and Eastern Germany from Britain.

It has been seen that the threat of a three ton limitation on the size of bombers confused and delayed the RAF's development of medium bombers. Needless to say it had a greater impact on the development of heavy bombers. In April 1934 the CAS (Ellington) wrote to the Secretary of State for Air (Lord Londonderry) to give him comparative data on British and Foreign aircraft. He explained that in heavy bombers Britain was behind, because while there had been the possibility of restrictions on size during the Disarmament Conference (1932-34), it had been thought unwise to invest in types which exceeded the proposed restrictions. Ellington said that special steps were being taken to improve the position.[96] He put these special steps to the Secretary of the Air Ministry (Sir Christopher Bullock) in June 1934. Ellington wrote,

> I have, therefore, proposed to the A.M.S.R. that a selected firm should be given a free hand to produce the best they can design to a very general and short specification. At the same time, we want to order from the Americans the best of the big aircraft which we can obtain in order that we may learn what there is to be learnt from their experience. I hope you will be able to assist in this matter.[97]

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[96] PRO: AIR 8/174, RAF Expansion; Performance of British & Foreign Aircraft: Position of German Air Re-armament, 20.11.34, document 621, CAS to SoS, 7.4.34

[97] 2/729, 17A, CAS to Secretary, 7.6.34

The Secretary gave his support to this proposal, although fearing that the Society of British Aircraft Constructors would object.[98] His fears were to be confirmed.

7.3.1 Origins of the Whitley: B.3/34

A draft Air Staff Requirement for a heavy night bomber had first been drawn up early in 1934. This document is given in the contents list of the relevant Air Ministry file, but is missing from the copy held by the Public Record Office. Nevertheless, it is evident from minutes which comment on the draft that the range proposed was the pre-existing standard for night bombers (920 miles), and that a limit on span was included. Harris (Plans) suggested that the range should be increased to 1,200 miles - 2,000 miles with overload, and again that the inclusion of a limitation on span in specifications was wrong. He commented that if this was due to the size of hangars, then "hangars are already proved an unessential luxury, except for repair purposes, & in wartime hangars will be the last place in which to keep aircraft."[99]

A later draft of "Air Staff Requirement for a Night Bomber Heyford Replacement"[100] was discussed by the 'Operational Requirements Committee' on 8th March 1934. (It was here that removal of specialisation of day or night bombers was discussed.) Following the meeting the DCAS (Ludlow-Hewitt) explained the rationale of the new bomber to Ellington.[101] In the interests of increasing the flexibility of the air force it was to be suitable for carrying loads other than bombs, in particular to have accommodation for not less than ten troops. It was believed then that this would not detract from its performance as a heavy bomber.

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98 ibid., Secretary to CAS, 19.6.34

99 ibid., Plans to F01, 6.3.1934

100 ibid., 5A

101 ibid., DCAS to CAS, 13.3.1934

Ludlow-Hewitt explained that the range had been increased to 1,250 miles at 190 mph (1,600 miles with auxiliary tanks), to give a radius of action of 500 (or 640) miles, which he said was adequate for a European war or a war in Afghanistan. The bomber was to depend upon self defence for its security and was to have gun turrets in the nose and tail plus upper and lower midships gun stations, all to be armed with a single machine gun. A limitation on span of 100 feet was included but was not thought to impose an undesirable limitation on design. Ludlow-Hewitt noted that oxygen would be required for the first time in a night bomber.

Compared with the most recent previous heavy night bomber requirement, that issued in 1927 (B.19/27, chapter 4.4.2), there was no change in bomb load, an increase in the number of guns from three to four (later rescinded), a modest increase in range and a substantial increase in speed.

The CAS (Ellington) agreed to the requirements, but suggested that more than two engines were needed to get reliability. He said that although the Air Ministry had always specified that a twin-engined aircraft should fly with one engine switched off, "we never in practice have got such an aeroplane; the most that the types we have adopted can do once they have been in production some time is to prolong the glide and so increase the choice of a forced landing place."[102] (In chapter 3.4.5 it is noted that the performance of aircraft in service seldom matched that attained by prototypes.)

This matter was investigated,[103] and it was concluded that if designers made full use of recent developments in aeronautical engineering - flaps, retractable

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102 ibid., CAS to DCAS, 16.3.34
103 ibid., 9A

undercarriage, low drag cooling and variable pitch propellers, a twin could meet the requirements and maintain height at full load with one engine out. But it was now thought that the ability to carry ten troops would cost 10 mph - which might be offset if a tail turret was deleted from the requirements.[104] These issues were to be important when the specification was later discussed with aircraft designers. Meanwhile, Dowding (AMSR) unsuccessfully sought to persuade the Air Staff to drop the requirement for troop carrying,[105] and the ADGB Command was consulted on the need for a tail turret.[106]

The AOC-in-C ADGB (Brooke-Popham), responded that he was personally against tail turrets but would abide by the recommendation of Harris,[107] "whose opinions must carry a good deal of weight". Harris was a strong advocate of tail turrets for night bombers.[108] Brooke-Popham later wrote to say that both his Western and Southern Area Commands favoured having a tail turret.[109]

When circulated early in July 1934 specification B.3/34 (later known as Specification No.1), dealt with the troop carrying issue by saying that the aircraft should be "designed to be entirely suitable for operation as a bomber and, in emergency, as a bomber transport." It called for a tail turret and a top speed of 225 mph.[110]

Ellington and Dowding pressed on with plans to hasten production by short-circuiting the normal competitive tendering procedure. They had intended to, "approach the three firms (Vickers, Handley Page, and Faireys) who alone have in recent years provided us with satisfactory heavy

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104 ibid., DTD to AMSR, 8.6.34
105 ibid., AMSR to DCAS, 11.6.34
106 ibid., DCAS to AMSR, 19.6.34
107 ibid., 13A, AOC-in-C to DCAS, 18th June 1936
108 2/688, DDOI to DCAS, 29.11.33
109 2/729, AOC-in-C to DCAS, 25th June 1934
110 ibid., 21A, Specification No. B.3/34. Heavy Bomber Landplane, 3rd July 1934

bombers",[111,112] but ominously Armstrong Whitworth were later included at their own request.[113] Dowding proposed that the firms should be told that "In view of the very superior performance of the Heavy Bombers in the possession of certain other powers", the Air Ministry could not accept the delay inherent in normal procedures,[114] but these words were not in the invitation to the four firms to discuss the specification. The invitation simply said that, "Owing to importance of obtaining early delivery of improved aircraft of the type, Department cannot accept delay". To this end the firms were told that the Ministry would consider amendments to the specification which would facilitate early delivery. They were also told that after a specification had been agreed, each firm was invited to put in a tender within one month for the supply of one prototype to be built and tested in eighteen months. The Ministry would then immediately choose to proceed with one (or more) tender.[115]

After meeting the heads of the four firms on 1st August 1934[116], Dowding wrote urgently to Ellington to say that "he had emerged rather battered from the fray". At a pre-meeting the firms had complained that the Ministry apparently planned to award a contract without seeing any drawings, and that therefore the contract would go to the firm most prepared to risk losing money. He quoted Sir Richard Fairey as asking if they wanted a bid for sixpence![117]

Despite these objections to procedure, the main meeting discussed the specification in detail, and some major changes were proposed. The firms said that the specified performance was possible only if the aircraft could be

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111 ibid., AMSR to CAS, 28.6.34
112 ibid., CAS to AMSR, 2.7.34
113 ibid., D. of C. to AMSR, 14.7.34
114 ibid., AMSR to D. of C., 5.7.34
115 ibid., 23A, 19th July 1934
116 ibid., 30A, Notes of Conference held on 1st August 1934
117 ibid., 29A, Dowding to CAS, 2nd August 1934

fully streamlined, and that as soon as defensive or operational excrescences were introduced the performance would be markedly reduced. Dowding told Ellington that he had therefore conceded that all hope of a bomber/transport must be abandoned, that only three gun stations should be specified, that arrangements for carrying 1,000 lb and 1,500 lb bombs should be deleted, and that although a tail turret had not been wholly given up, it would cost 10 mph in speed. He had been advised that the top speed with a tail turret would be 205 mph. The aircraft could have a high performance without defence, but Dowding doubted that the Air Staff would accept that.

Ellington replied to say that he left it to Dowding to settle contract arrangements, commenting that "designers who have frequently pressed for a free hand are now afraid of receiving it".[118]

Attempts to negotiate with the four firms new contractual arrangements which retained some element of competition failed.[119] The Air Ministry then decided to seek to place one order at a low price, bearing in mind that the chosen firm was likely to get a production contract. Dowding thought that Vickers or Armstrong Whitworth were likely to achieve the quickest delivery, but Ellington "was not prepared to complicate such an important experiment with the additional factor of geodetic construction, since, although showing great promise, we have had no practical experience of it yet." This eliminated Vickers, and Dowding met Sir John Higgins of Armstrong Whitworth and agreed on a price of £64,000 for two machines - the other firms had asked for £60,000 for one.[120] A modified specification[121] (later referred to as No. 2) was issued in August 1934. This took account of the firms' reactions to the original specification.

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118 ibid., Ellington to AMSR, 2nd August 1934

119 ibid., Notes of meeting held by Director of Contracts, 3rd August 1934

120 ibid., File Note by AMSR, 16.8.34

121 ibid., 40A, Corrigendum No.1 to Specification B.3/34, 7th August 1934

No sooner had these steps been taken than doubts arose about Armstrong Whitworth's capabilities, but Dowding rejected attempts to encourage Vickers to submit a private venture tender to B.3/34.[122,123,124]

7.3.2 Americanisation: B.1/35

In October 1934 arrangements were being made to consider the Experimental Aircraft Programme for 1935, and Group Captain R.H. Peck (DDOI) raised the question of a new heavy night bomber. He feared that Armstrong's would produce an unsuccessful aircraft, and proposed that a new specification should be issued.[125] After some discussion it was decided to await the return of Air Commodore R.H. Verney (the new DTD) from his visit to American aircraft companies before deciding upon a new heavy bomber specification.[126,127]

Early in 1935, when Verney had returned from his visit to America, he put down his thoughts on the heavy bomber issue. He suggested that the RAF should aim for something not only superior to the current Martin bomber, but equal to or better than developments which were in hand at Martin and Boeing. Verney put forward a redraft of heavy bomber specification B.3/34 to give an "Americanised" version. In this the maximum speed of 230 mph was little more than the Ministry's first hopes for B.3/34, but the normal bomb load was increased from 1,500 lbs to 2,000 lbs and the range to 2,000 miles - substantially greater than the 1,250 miles of B.3/34.[128] It will be seen in chapter 8

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122 2/716,_13A, DTD to AMSR, 22.8.34
123 ibid., AMSR to DCAS, 22.8.34
124 ibid., DCAS to CAS, 28.8.34
125 ibid., DDOI (for DCAS) to CAS, 12.10.[34]
126 ibid., 1A, note to DCAS, [15.10.34],
127 ibid., note by AMSR, 20.11.34
128 PRO: AIR 2/2820, Warwick Heavy Bomber - Spec B1/35 - Type Requirements, DTD to AMSR, 12.1.35

that 2,000 miles was the range requirement thought to be needed for a war with Germany.

Verney's ideas were incorporated in a paper written for a meeting of the 'Operational Requirements Committee' held on 20th February 1935.[129] This paper gave the history of B.3/34, and referred to Verney's Americanised version as Specification No.3. The maximum speed, range and bomb load of No. 3 were as proposed by Verney. Three gun stations (including a tail turret) were specified - each with a single Lewis gun.[130] Liptrot estimated that with two Rolls-Royce Merlins Verney's performance aims could not quite be met.[131] A design bomb load of 2,000 lbs and a range of 2,000 miles could be met at 150 mph , but at normal (maximum continuous) rpm to give a cruising speed of 195 mph a range of only 1,500 miles was possible.

Following the meeting the operational requirements were revised to accord with Liptrot's estimates. They were circulated to industry in March 1935, now designated B.1/35. The preamble recognised the significance of war with Germany and the consequent likelihood of deep penetration of hostile airspace. It said that, "During operations it is necessary to reduce the time over enemy territory to a minimum. Therefore the highest possible cruising speed is required." In addition to the normal bomb load (2,000 lbs) and range (1,500 miles), firms were told that it was hoped to carry 1,000 lbs for 1,800 miles and 4,000 lbs for 900 miles". Internal bomb stowage for the maximum load was specified.[132]

A new feature was the specification of airfield performance in what the DCAS described as "looser terms".[133] It was required to be reasonable for average

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129 ibid., 5A, "Air Staff Requirement for a Heavy Bomber Landplane (Heyford and Hendon Replacement)"

130 ibid., 5b, Operational Requirements of Nos. 2 and 3

131 ibid., 6B, RDA3 to DTD, 21.2.35

132 ibid., 17C, Air Staff Requirements for a Heavy Bomber Landplane

133 ibid., DCAS to AMRD, 27.2.35

aerodromes, with 500 yds to clear 50 feet in both landing and take-off given as guidance. Take-off distance was to become a major issue in the next generation of bomber specifications.

The full specification B.1/35 was issued on 8th May 1935.[134] In the section on "Gun Stations" this said that, "The ideal to be aimed for is that the gun stations should be dragless when the bomber relies solely on speed for evasion, but capable of powerful defensive fire when required." This powerful defence was to be provided by single Lewis guns at the front and midships stations but now with two at the rear station.[135]

It will be remembered that when in June 1934 Ellington was considering a special procedure to hasten a heavy bomber replacement, he had consulted the Secretary of the Air Ministry and gained his support. Dowding had later used the absence of competition to obtain a much reduced price for two prototypes to B.3/34 from Armstrong Whitworth. Thus it can have been no surprise when, in March 1935, the Secretary wrote to Ellington and Dowding to express his great concern over the way in which dealings with that company were proceeding. It appeared to him that the B.1/35 project would supersede B.3/34 and that Armstrong would get few orders.[136] Dowding told Ellington that Bullock was right to be concerned, but advised that Armstrongs would get orders to equip three to four squadrons.[137]

Of course B.1/35 had been initiated precisely to replace Armstrong's design to B.3/34 (the original Air Staff Requirement document was entitled "B3/34 Replacement"[138]). The reason was that no sooner had a contract been awarded

[134] ibid., 24A, Specification No. B.1/35. Heavy Bomber, 8th May 1935
[135] ibid., 24A, paragraph 11
[136] ibid., Secretary to CAS and AMRD, 16.3.35
[137] ibid., AMRD to CAS, 3.4.35
[138] ibid., 6A

to Armstrong than the Ministry lost confidence in their capabilities. In the event, B.1/35 did not lead to a production order as a bomber, for it became absorbed into the next stage of bomber development as explained in chapter 8. The Armstrong Whitworth Whitley was built in quantity,[139] and was the RAF's only heavy night bomber in service when war broke out in 1939.

7.4 SUMMARY

In this chapter it has been shown that RAF bomber development in the early 1930s was initially dominated by arguments over the merits of single- and twin-engined day bombers. Sir John Salmond effectively overruled the Air Staff's preference for single-engined types, and from then on single-engined light bombers lost favour - a trend which was strengthened by the recognition of Germany rather than France as the enemy for planning purposes.

A very important development in those years was the acceptance that advances in aeronautics had made redundant the distinction between the day and night classes of bomber. Thus at the end of the period covered in this chapter the heavy bomber requirement B.1/35 marked not only the transition from France to Germany as the operational target, but also the end of the classification of the heavy bomber as primarily a night bomber.

As with Air Staff requirements for fighters in the early 1930s, bomber requirements sought to take full advantage of developments in aviation technology in other respects. They led to aircraft which in terms of bomb load and performance were at least as good as those developed elsewhere, but shared with the United States and the emerging German air forces the neglect of the bomber's defensive firepower.

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139 Thetford, page 30

In chapters 4 and 6 it is shown that in the years 1927 to 1933 the Air Ministry planned or envisaged fighters armed with four, six, and eight machine guns. Eight guns, each with a high rate of fire, were firmly specified in 1934. Yet the bombers specified in that period called for no more than two to three single machine-gun stations, with only the final form of B.1/35 specifying two guns in its tail turret. It is true that the RAF placed great reliance on the combined defensive power of a formation of bombers, but the individual bomber armament it specified was no more than that previously considered necessary for a formation to combat fighters armed with but two guns - and these with a relatively slow rate of fire. This policy was continued, even though, as discussed in chapter 6.1, the Air Ministry was well aware that RAF bombers would be particularly vulnerable to multi-gun fighters. Indeed, in the context of the ideal "dragless" (i.e., remotely controlled) gun installations sought in specification B.1/35, the Operational Requirements section admitted that bombers armed with only two/three guns firing aft were at a serious disadvantage against eight-gun fighters.[140]

It will be seen that the in the next generation of bombers the Air Staff continued to allow the armament of its bombers to lag behind that of its fighters.

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[140] PRO: AIR 20/9, Defence of Bombers, OR to DCAS and DSD, 10.1.35

8. BOMBERS TO ATTACK GERMANY

8.1 INTRODUCTION

As noted in the previous chapter, the recognition of Germany as the potential enemy in Europe forced a re-appraisal of bomber requirements. In May 1935 the Interim Report of the Sub-Committee on Air Parity - which was in response to the fears aroused by the reported increase in the German Air Force - included a map which showed that a radius of action of 500 miles would be needed to attack Berlin and 700 miles to attack the Silesian industrial region. It noted that even the RAF's existing heavy (long-range) bombers could not attack Berlin with a full bomb load.[1]

Raids on such distant targets would involve deep penetration of hostile airspace, and two ways of achieving this were considered - speed and armament. Speed would both reduce the length of time over which the bombers were exposed to attack and make interception more difficult. Increased armament would, it was thought, enable bombers to defend themselves against repeated attacks. Night attacks were a third option, but these would sacrifice bombing accuracy, and were planned only to maintain continuity of the offensive.

The conflict between speed and armament dominated the discussion of the operational requirements for bombers up to the outbreak of war in 1939. It will be seen that although there was some advocacy of speed as the primary defence, the issue was more one of bomber weight, for it was argued that the heavier the bomber the more possible it was to have both speed and - what was believed to be -

[1] PRO: AIR 8/196, Royal Air Force Expansion - 1935, Sub-Committee on Air Parity' Interim Report, 8th May 1935, Appendix B and para.32

adequate armament. Adequate meant not only many guns, but also an increased ammunition load, for as Air Vice Marshal W.R. Freeman (who replaced Dowding as AMRD in April 1936) explained, this "should be governed by the range of the aeroplane, because, as the range increased so did the length of time during which fighting might take place."[2] Furthermore, as has been noted in the context of fighter development, the use of more powerful - and heavier - engines to obtain high speed inevitably led to aircraft of increased weight. How to get these heavy aircraft into the air became a major problem, with the solution first sought through schemes for assisted take-off.

These issues were the core of the discussion of new medium and heavy bombers in 1936, and of the search for an "Ideal" (standard) bomber in 1937-39 which is discussed in chapter 9. It will be seen that it was such technical considerations which led to a great increase in the weight of RAF bombers.

Some writers have interpreted these developments as indicative of a change in bombing policy. For example, Smith suggests that whereas in the Wellington and Hampden the Air Staff had found "its equipment-constant" (sic) type, in 1935-36,

> The Air Staff were in fact already working on the possibility of producing a much heavier bomber. In other words they were moving towards a final decision, without compromise, on fundamental strategic priorities.[3]

Similarly, the Air Historical Branch narrative on the pre-war evolution of Bomber Command claims that, via discussions on RAF Expansion Scheme F, the Cabinet,

> established as the accepted policy that from henceforward the home-based bomber force was to be

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[2] PRO: AIR 9/77, Operational Requirements Committee 1936-39, Minutes of 27th May 1936, Item 4 Armament

[3] Smith, M., page 237

> regarded as an offensive and potential war-winning weapon rather than merely to as an instrument for reducing the weight of enemy air attack by counter-offensive measures. This placed the emphasis in bomber development squarely upon hitting power - upon range, bombload, and fighting capacity.[4]

But as has been shown in chapter 2.2.1, it had never been RAF policy to concentrate its offensive upon the reduction of an enemy's scale of attack, as Air Staff Memoranda 11 and 11.A on the 'Correct Objective' made abundantly clear. Moreover bomber development had always been concerned with range, bomb load and fighting capacity, these attributes not being the prerogative of big bombers.

In a similar vein, Postan claimed that, "Throughout the early years of expansion, the Air Staff showed every predilection in favour of the heavy long-distance bombers."[5] But the expansion was to meet the threat from Germany, and as major German targets were at a long distance, no predilection was required - common sense would suffice. Indeed, the AHB narrative noted that these requirements inevitably led to bombers of greater size.[6]

The straightforward technical requirements to get the range, and particularly the speed, seen as needed to attack targets in Germany inevitably led to much heavier bombers than had been needed to bomb Paris. That there was no big bomber policy as such is evident from a comment made when concern with the size of the new heavy bomber (B.12/36) was voiced at the Operational Requirements Committee. The Air Staff stated that, "in drafting the requirements they had visualised using the medium bomber as the backbone of the Striking Force supplemented by a certain number of these heavy bombers."[7]

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[4] 41/39, page 132
[5] Postan, page 78
[6] 41/39, page 132
[7] 9/77, Minutes of 27th May, para.7

It will be seen that the normal bomb load of the new medium bomber (P.13/36) - the planned backbone of the striking force - was reduced to below that expected of the types it was to replace to obtain a much higher speed. The Ideal Bomber study also demonstrated the major influence of speed on weight. Neither in Air Staff thinking at the time nor in technical feasibility was there an alternative small bomber policy which they might have adopted for war with Germany.

In the many RAF files which concern bomber operational requirements which have been examined in the course of the current research a change in bombing policy is never mentioned as their *raison d'etre*. What is emphasised is the need for high speed and powerful armament to carry out the bombing policy which had been adopted in the early 1920s.

The following sections of this chapter deal first with the evolution of the bomber requirements B.12/36 (Stirling) and P.13/36 (Halifax and Manchester). Then section 8.3 discusses the significance of a number common features. Section 8.4 reviews the outcome of the 1936 bomber specifications in relation to the aircraft which operated in the war.

8.2 THE 1936 BOMBERS

In the formulation of the 1936 bomber requirements Ludlow-Hewitt's aim to drop special day or night classes of bomber was put into effect. Both the new medium and heavy bombers were seen as capable of day and night operation, but their primary mode of operation was to be by day - Webster and Frankland say that 75% of sorties were expected to be by day.[8] Indeed, the Minutes of the 14th

[8] Webster, Sir Charles, and Frankland, N, The Strategic Air Offensive against Germany, Vol I, 1961, page 100

meeting of the Bombing Committee, held in April 1937 record that, "The Chairman opened the meeting by saying that the subject of night bombing was now, *for the first time*, before this Committee."[9]

That day operation was expected of the bombers planned in 1936 is confirmed by the Air Staff's comments early in 1939 on a proposal to fit an under turret to Pegasus engined Wellingtons, which would lead to reduced performance. The Director of Operational Requirements argued against the proposal. He suggested that,

> When more bomber aircraft are available it may be possible to relegate the Pegasus type to night operations, for which powerful defensive armament is not so essential as for day operations.[10]

But the Operations branch supported the fitting of an under turret, because it saw that the Pegasus Wellington,

> must form a considerable proportion of our day bombing attack until the Merlin Wellington, Stirling, Halifax and Manchester come into Service in quantity.[11]

In chapter 10 it is noted that as each of the types derived from the 1936 Air Staff Requirements came into service during the war, it was sent on daylight operations in the hope that the deficiencies of the previous generation of RAF bombers had been overcome. They had not, and the bombers derived from the 1936 specifications became the mainstay of the RAF's night bomber force. This has led to the common misconception that the specifications were originally for heavy night bombers.

Thus Divine wrote,

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[9] PRO: AIR 20/9830, Minutes of Bombing Committee Meetings, 1-24, 14th meeting, para. 1, italics added

[10] PRO: AIR 2/1964, Wellington Vickers Bomber to Specification B.9/32. Type Requirements, 55A, DOR to ACAS, 15.2.39

[11] ibid., DDOps(H) to ACAS, 20.2.39

> In 1936 Air Ministry views - three years late as usual - swung towards heavy night bombers. Two specifications, P.13/36 and B.12/36, were circulated; one, for a four-engined big bomber; one, for a two-engined 'small big bomber'.[12]

Divine has the specifications in the wrong order; P.13/36 was to be twin-engined. Needless to say, Divine gives no clue as to who was specifying similar bombers three years earlier.

Greer refers to, "the design of night bombers (Wellington, Stirling, and Lancaster) by the British for area attacks at night".[13] R. Freeman, in a reference to RAF policy in the inter-war years, says that, "the new four-engine heavy bombers in large scale production in 1942 were, from the outset, designed for night attack."[14]

In fact, as explained above and evident from the following discussion of the 1936 bomber operational requirements (and those for an Ideal Bomber), the Air Staff were then planning primarily for bombing by day. This is why the armament and ammunition load were based upon the need to fight off repeated attacks by enemy fighters, and a high speed was needed to reduce exposure to such attacks.

8.2.1 Common Features - Speed and Overload

In chapter 7.2.1 it is noted that in 1934-35 the Air Staff were concerned that the medium bombers then under development to specifications B.9/32 and P.27/32 were obsolete, particularly in terms of speed. They wished to start on a new medium bomber in 1936,[15] although the prototypes to the 1932 specifications had not flown.[16]

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12 Divine, page 189
13 Greer, page 45
14 Freeman, R., The U.S. Strategic Bomber, 1975, page 42
15 2/1402, 3A, Experimental Aircraft Programme for 1936; Air Staff Requirements and Priority
16 Thetford, pages 278 (Battle), 313 (Hampden), 554 (Wellington)

The Air Staff also wished to start the development of a new heavy bomber in 1936, although Armstrong Whitworth's design to B.3/34 had also not flown, and, as explained in chapter 7.3.2, a replacement for it had been specified in 1935 (B.1/35). The Air Staff were seeking a larger alternative range and bomb load than B.1/35,[17] and appear to have been influenced by reports of a new American four-engined bomber (this seems to have been either the Boeing XB-15 or XB-17 - the prototype "Flying Fortress"[18]), and by thoughts from the ADGB Command on resurrecting the concept of a 'Giant' bomber - which Oxland said would now have to have a very high performance.[19]

In October 1935 new medium and heavy bombers were included in the proposed experimental aircraft programme for 1936.[20] First thoughts on the medium bomber[21] were to call for a bomb load no greater than that then thought possible for the B.9/32 Wellington, viz. 2,000 lbs.[22] It will be seen that this was to be reduced to 1,500 lbs, and then, to get a higher speed, to 1,000 lbs. The new heavy bomber was first planned to carry the same bomb load of 2,000 lbs as had been specified for B.1/35. These bomb loads were under normal operating conditions, i.e., with a take-off to 50 feet of 500 yards.

Under normal conditions the medium bomber was to have a range of 1,000 miles - not 1,500 miles as given in the AHB narrative.[23] It was the heavy bomber for which a normal range of 1,500 miles was specified. These ranges were to be achieved at a speed based upon "two-thirds maximum engine power",[24] rather than on the maximum permissible

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17 2/1402, 15A, Appendix A,

18 Freeman, page 22

19 2/1402, 7A, Notes on a Preliminary Discussion on the Air Staff Requirements for the Experimental Aircraft Programme for 1936, 4th October 1935

20 ibid., 7A

21 ibid., 12A, Appendix "A", draft Air Estimates 1936

22 PRO: AIR 9/82, The Ideal Bomber, 12A, Table of performance of bombers, DDOR, 26.8.37

23 41/39, page 136

24 9/77, Minutes 27th May 1936, Item 2. Performance

rpm for continuous running that had been previous practice (chapter 3.4.5). Even so, such were the advances in aero-engines that it was hoped to get a considerable increase in cruising speeds. In addition, for both the new medium and heavy bombers a reinforcing range of 3,000 miles was sought.

It is clear that the main element in the Air Staff's thinking was to seek an increase in speed over that of earlier bomber specifications. This need had been emphasised by Lord Weir in comments on the RAF's Expansion Programme. In regard to bomber development he had suggested that "the factor of speed be given the leading place".[25] However, large increases in range and bomb load also appeared possible when the requirements for both classes were enhanced to take account of operation in overload conditions.

Two stages of overload operation were envisaged, first by extending the take-off from 500 yards to 700 yards, and second, by launching the bombers by catapult. Extended conventional take-off was expected to give a larger bomb load at a range of 2,000 miles for both classes. This would give the operational radius of action needed to attack Eastern Germany. Catapult take-off was expected to give an operational range of 3,000 miles with a further increase in bomb load, or - most significantly - up to eight-times the normal bomb load at shorter ranges.

Some writers on the development of the aircraft operated by the RAF in the Second World War have noted the provision for catapult take-off in specifications B.12/36 and P.13/36. Barnes says that the Air Staff's "technical advisers" had "even predicted that some form of catapult launching (referred to as a 'frictionless take-off' device) would be essential on existing airfields".[26]

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25 6/43, The March 1937 Programme and the Strategical and Tactical Basis on which its Materiel is founded, 17th July 1935

26 Barnes, Shorts, page 370

Andrews and Morgan refer to "a catapulting capability for short take-off".[27] Mason correctly notes that catapult launching was associated with heavy loads for the Short B.12/36,[28] and the Avro[29] and Handley Page[30] designs to P.13/36, but dismisses the concept with the comment that, "experiments (which) were to fascinate the RAE, if no one else, for years to come".[31] It will be seen that this was far from the case.

The following sections of this chapter show how catapult take-off came to be introduced first for the heavy bomber B.12/36. Requirements for the new medium bomber, P.13/36, were then also written to exploit catapult take-off, and to include a facility to serve as a torpedo bomber. Both the catapult scheme and torpedo carrying were later abandoned, but by then they had exerted a major influence on the design of aircraft to the 1936 specifications.

8.2.2 Heavy Bomber B.12/36 (Stirling)

In October 1935 the Air Staff's wish to start development of a new heavy bomber was discussed with the Directorate of Technical Development.[32] Captain Liptrot produced an estimate of what might be obtained from a bomber with four Merlin engines. With the same military load (i.e., mainly crew, bomb load and armament) and range as B.1/35, he estimated that a maximum speed of 275 mph and a cruising speed of 230 mph were possible - both a considerable improvement on B.1/35. However, the DTD (Verney), whose visit to America had generated the B.1/35 specification, thought that, "the heavy bomber position was well met by the B.1/35; he was very chary of supporting projects for very large aeroplanes". He said that making aircraft too

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27 Andrews and Morgan, Supermarine, page 320
28 Mason, British Bomber, page 314
29 ibid., page 323
30 ibid., page 330
31 ibid., page 314
32 2/1402, 7A

large for their purpose had been one of the faults of the past. Verney's alternative proposal is the real key to the origin of the RAF's future heavy bombers.

> He suggested that the future requirements of the Air Staff beyond the B.1/35 might be met by incorporating them in the bomber which would have to be designed to meet the conditions of the Catapulting Scheme now under consideration;

Verney claimed that, "The result would be a bomber just as powerful, capable of quite as much range, greater speed, and it would be smaller and cheaper to produce." He noted that "the catapult bomber would be quite effective for use on ordinary aerodromes at a reduced load."

The head of the Operational Requirements section (Oxland) asked for particulars of the Catapult Bomber, so that the Air Staff could consider this idea.

Provision for a "Large Catapulting Type" had been included in the Air Estimates for 1935.[33] It was then described as, "A type for long range and high speed special operation, viz. a high cruising speed made possible by catapulting, refuelling in the air, or launching by other aircraft". Following Verney's proposal, this project (B.4/36) was merged with the new heavy bomber, and redesignated B.12/36.[34] One consequence was that development of a heavy bomber was moved ahead of that of the planned new medium bomber.[35]

The Air Staff reconsidered their requirements for a heavy bomber so as to take account of the catapulting scheme. They decided that,

> It should be an aircraft that can exploit the alternatives between long range and very heavy bomb

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33 2/716, DDOI to CAS, 12.10.34, Appendix 6B, Air Estimates 1935

34 ibid., Note by DDOR, 16.9.37

35 2/1402, DTD to AMRD, 21.4.36

> load which is made possible by catapult launching in an overloaded condition.[36]

In putting draft requirements to the DCAS (Courtney) in May 1936, Oxland (now Group Captain and Deputy Director Operational Requirements) said that, despite the weight of the onboard catapulting equipment, the new aircraft would in normal operation give some advance over the B.1/35 specification which it was to replace. It would have a cruising speed 35 mph higher and a doubling of defence - with two guns in a front turret, two amidships (under the fuselage) and four in the tail. With catapult take-off the new bomber would have a vastly increased striking power - a range of 3,000 miles with 8,000 lbs of bombs or of 2,000 miles with 14,000 lbs.

Oxland said that it might be thought that a four-engined aircraft would be unduly large, but that a 100 feet limit had been placed on span, and RDA3 (Liptrot) agreed that the performance could be obtained within that limit. A four-engined type was proposed after a study of foreign developments and plans for such heavy bombers, and that,

> The speeds of all foreign heavy bombers, with the exception of the Italian S.79, falls considerably below the speed we hope to attain. The French and U.S.S.R. are in the region of 140 m.p.h., the German and U.S.A. in the region of 200 m.p.h., and the Italian 250 m.p.h.[37]

(The S.79 was a relatively short range three-engined aircraft.)

The Operational Requirements Committee met on 27th May 1936 to discuss the new bomber, B.12/36.[38] The committee's discussion first centred round the size of the proposed aircraft. Verney explained that the size had been selected to take full advantage of catapult take-off. Although the new bomber it was expected to be no larger

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[36] PRO: AIR 2/2629, Heavy Bomber Landplane (4 Engines) Specn. B/12/36 Type Requirements, 1A, Air Staff Requirements for a 4-engined heavy bomber landplane, undated

[37] 2629 ibid., DDOR to DCAS, 8.5.36

[38] 9/77, Minutes of 27th May 1936

geometrically than the immediately preceding heavy bomber project, B.1/35, with maximum overload it would be much heavier than any aircraft then operated by the RAF. The issue of weight was discussed in terms of technical and operational feasibility, not of bombing policy. The concern was whether a smaller twin-engined aircraft was preferable to the four-engined aircraft of the draft requirement. A force of twin-engined aircraft was seen as more reliable, because the unserviceability of an engine would reduce the striking force less - assuming that there would be a larger number of smaller bombers. On the other hand, a four-engined aircraft could carry greater defensive firepower. In view of the deep penetration flights that were expected, this was taken as the decisive argument.

The representative of the ADGB (Air Commodore A.D. Cunningham) put the Command's view that it was better to go for a higher speed at the expense of defensive armament,[39] but this was not accepted. It will be seen that when the Command was represented by its AOC-in-C at the committee meeting on the new medium bomber, it was to be more successful in arguing the case for speed.

Some interest was expressed in the operation of the proposed catapult system, but there was no questioning of where and when they would be built, or the state of development and likelihood of success. Verney's claim that, "this was a method of getting a large load without having to build a huge aeroplane",[40] was apparently accepted as an established fact.

The committee's views on the composition of the bomb load had important consequences. It was accepted that the ability to carry 2,000 lb bombs was needed only for attacking ships - underlining that the heavy bomber was no

[39] ibid., para. 27
[40] ibid., para.21

longer seen solely as a night bomber. Otherwise it was thought unnecessary to provide for bombs larger than 500 lbs each for use against land targets. Space would therefore have to be found for the twenty-eight 500 lb bombs which would make up the maximum overload of 14,000 lbs, and this would lead to bomb bays in the wings as well as in the fuselage - but with no individual bomb cell larger than that needed for the 2,000 lb bomb.

When Oxland summarised the committee's conclusions he emphasised four points. One was the advantage that the larger size of bomber would give if the numbers of bombers were to be limited by International agreement. Second was the ability to carry seven 2,000 lb Armour Piercing bombs and so to support the Fleet and sea-borne trade. Third was the aircraft's suitability for home defence and to reinforce overseas. Fourth was the avoidance of production problems by obtaining a large loading capacity without having to build a huge aircraft. Oxland demonstrated the relative economy of the heavy bomber as compared with two medium bombers to give the same bomb lift - a meaningful comparison only if the range was the same, which was so only with overload take-off.[41]

In seeking the approval of the CAS to the requirements for a new heavy bomber, the DCAS (Courtney) also stressed the intention to exploit catapult launching, and the relative economy of the heavy bomber, but said there were reasons for also needing a medium bomber - "amongst which is the possibility in the future of a renewal of the idea of an International agreement for a limitation of all-up weight."[42] Thus whilst Oxland argued that the case for needing a new heavy bomber was that aircraft numbers might be limited by international agreement, Courtney argued that the case for a new medium bomber was that aircraft weight might be so limited. Perhaps past experience of

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[41] 2/2629, DDOR to DCAS, 11.6.36
[42] ibid., DCAS to CAS, 12.6.36

disarmament discussions warned them that both fears were justified.

Neither Oxland nor Courtney made any reference to a change in bombing policy, nor did the CAS (Ellington) when he approved Air Staff Requirement B.12/36. He did, however, ask if any consideration had been given to replacing some of the 0.303in machine guns with 20mm cannon.[43] It will be recalled from chapter 6.2.2 that Ellington had earlier encouraged the equipment of RAF fighters with cannon.

Officers of the ADGB Command had also considered the possibility of heavier armament when they saw the first draft Air Staff Requirements for B.12/36,[44] but had not raised it at the Operational Requirements Committee meeting.

The Air Staff's somewhat specious answer to Ellington's query is discussed in detail in section 8.3.4. It must bear a large measure of responsibility for the inadequate armament of RAF bombers in the Second World War. The DDOR (Oxland) advised that 20mm cannon armament for bombers was neither feasible nor necessary, and the DCAS (Courtney) added his own view that little was known about the application of larger calibre guns to aircraft.[45] (In fact the RAF had been experimenting with the large C.O.W. gun since 1917.[46]) Courtney did refer to the Air Ministry's cannon fighter prototypes, but suggested awaiting experience with these before considering an application to bombers.

Faced with this advice, Ellington had little option but to agree that cannon armament should not be tried in B.12/36. Nevertheless, he did not want the issue postponed until

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43 ibid., CAS to DCAS, 12.6.36

44 PRO: AIR 16/159, Four Engined Heavy Bomber Landplane Specification B12/36 Air Staff Requirements for, SASO to Air Ops., 21.5.36

45 2/2629, DCAS to CAS, 24.6.36

46 PRO: AIR 2/732, Multi-Engine Bomber: Notes by Armament Experimental Station, Report on Sinaia Aeroplane, 18th April 1918

the fighters were available - which he correctly expected to be several years.[47]

Arrangements were made to circulate the Air Staff Requirement for a heavy bomber to aircraft manufacturing firms. The DTD (Verney) asked that Armstrong Whitworth, Vickers, Handley Page and Boulton Paul should be told that they would be invited to tender,[48] but later agreed[49] to a request from the Operational Requirements branch that Short Bros. should be included on the list of firms to be invited to tender. The branch had seen a design at Shorts which it said came close to the requirement.[50]

The full specification, "No. B.12/36 Heavy Bomber", was issued in July 1936. It stated that the military load to be carried during acceptance trials need include only 2,000 lbs of bombs, for this was the design case for a normal (500 yard) take-off. But the section of the specification on "Structural Strength" decreed that the aircraft must be designed for launching at "limiting weight" from a catapult which imposed an acceleration of two-and-a-half "g" at the end of a launch.[51]

Goulding and Moyes claim that at the Operational Requirements Committee the Goshawk engine was much favoured,[52] but in fact the Committee had simply been told that Liptrot's estimates of feasible performance had been based upon the use of four Goshawks.[53] The significance of this was that his original assessment of the potential of a four Merlin (then put at 850 hp[54]) bomber had been overtaken by hopes of developing a smaller aircraft for use with catapult take-off. Nevertheless, four engines

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[47] 2/2629, CAS to DCAS, 25.6.36
[48] ibid., DTD to DoC, 19.6.36
[49] ibid., DTD to C4C [Contracts Dept.], 17.7.36
[50] ibid., OR1 to RDA3, 13.7.36 and [11A], DoC to Short Bros., 18th July 1936
[51] ibid., 26A, Specification No. B.12/36 Heavy Bomber, dated 15th July 1936, para. 111
[52] Goulding and Moyes, page 41
[53] 9/77, Minutes of 27th May 1936, para. 2
[54] PRO 6/50, Expansion Progress Meetings July- 1937, EPM 91(37), para.2

were still desired and the Goshawk of 700 hp was the right size on which to base the project study.

Prototypes to specification B.12/36 were ordered from Supermarine and Short Bros.. Development of the Supermarine aircraft was delayed by work on the Spitfire, and by the loss of prototypes in an air raid in 1940. The Short Stirling went into production. Thus, as with the previous heavy bomber B.3/34, a production order was given to a firm which was not on the DTD's original list of those he wished to invite to tender - with a similar unsatisfactory result.

8.2.3 <u>Medium Bomber P.13/36</u> (Halifax and Manchester)

The new medium bomber was intended to form the "backbone of the Striking Force" as quoted above. It was hoped that it would also meet the requirements of the General Reconnaissance, General Purpose, and Torpedo Bomber classes.

For some years the desire to reduce the number of types in RAF service centred on the possibility of bringing together some of these four classes. In 1930 Newall (then DCAS) had proposed that the General Purpose and Torpedo Bomber classes could be combined.[55] Also in 1930, Welsh, in a paper which reviewed aircraft in service and under construction, noted that it was intended that in future the medium bomber would double as a coast defence torpedo bomber.[56] This point was reinforced in 1931 by Plans branch, who, as discussed in chapter 7.2, saw that one advantage of a twin-engined day bomber was that it would be capable of torpedo carrying.

[55] 20/68, DCAS to CAS and AMSR, 14.10.30

[56] 9/37, Folio 18, Types of Aircraft at Present in the_Service and Types Under Construction, February 1930

A draft Air Staff Requirement P.13/36 for a multi-role medium bomber was prepared for discussion by the Operational Requirements Committee. It followed that of the heavy bomber B.12/36 in aiming to exploit overload operation with a long take-off and with the catapult scheme. It was hoped that a normal (500 yard take-off) bomb load of 1,500 lbs and range of 1,000 miles could be increased to 2,000 lbs and 2,000 miles with a 700 yard take-off, and to 3,600 lbs and 3,000 miles - or 8,000 lbs and 1,800 miles - with catapult take-off. Defensive armament was to be a four machine-gun tail turret and a two-gun front turret.[57]

The Operational Requirements Committee met on 22nd June 1936 to consider P.13/36.[58] A Table had been prepared which gave two twin-engined examples. Case I had a cruising speed of 220 mph, and case II, a larger aircraft, 250 mph. At the meeting Oxland explained that the Air Staff had called for a (ferry) range of 3,000 miles so as to get world-wide use, as with B.12/36, and that they hoped to make use of catapulting. He asked the committee to consider if a cruising speed of 220 mph was adequate, or if a higher speed was sufficiently important to justify a larger aircraft,[59] - remarks which are hardly indicative of an organisation wedded to a big bomber policy. There was much discussion of this point, with the ADGB Command stressing the need for a speed higher than that offered even in case II.

Now a key feature of the meetings on new aircraft requirements set up by Ludlow-Hewitt in 1933 was that they included the representatives of the operational Commands of the RAF. Thus the papers on P.13/36 had been sent to the ADGB Command before the committee meeting, and the AOC-in-C (Air Marshal Sir John Steel) had sought the views

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[57] 9/77, Draft Air Staff Requirements for a twin engined Medium Bomber landplane Specification P.13/36, 10th June 1936

[58] ibid., Minutes of Meeting to consider P.13/36, 22nd June 1936

[59] ibid., Minutes of 22nd June 1936, para. 5

of his officers. The response from his Headquarters staff was that speed was preferable to armament,[60,61,62] and this view was supported by No.1 (Bomber) Group, who wanted a speed of 300 mph.[63]

Steel pursued this line at the Operational Requirements Committee. He suggested that it was the amalgamation of the requirements of four classes which had led to a loss of performance in the medium bomber role, and he was concerned about the weight of catapulting equipment. He also suggested that a bomb load of 1,000 lb would suffice, with the comment that, "If a greater load was required, more than one aeroplane could be used."[64] This remark underlined the RAF's continuing belief in the accuracy and effectiveness of bombing, and perhaps the operational Command's scepticism in regard to overload operation.

Oxland insisted that the Air Staff had first formulated requirements for a medium bomber, and had then considered if it could be used for other purposes. It was not these which caused a loss of speed. As regards the request for 300 mph, Liptrot explained that a reduction in range and bomb load would be necessary to get this speed - a longer take-off would not be sufficient.[65]

No conclusion was reached on 22nd June, and a second meeting was arranged to consider new options aimed at a higher cruising speed.[66] For this meeting, held on 29th July 1936,[67] three further examples were added to those considered earlier.[68] In these the normal bomb load had

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[60] PRO: AIR 16/194, Twin Engined Medium Bomber Landplane. Specification P.13/36. Air Staff Requirements for., Air Ops1 to SASO, 12.6.36
[61] ibid., Navigation to Air Ops, 15.6.36
[62] ibid., Chief Signals Officer to Air Ops, 16.6.36
[63] ibid., Headquarters No.1 (Bomber) Group to Headquarters, ADGB, 17.6.36
[64] 9/77, Minutes of 22nd June 1936, paras. 10 and 29
[65] ibid., Minutes of 22nd June 1936, para. 52
[66] ibid., Minutes of 22nd June 1936, para. 51
[67] ibid., Minutes of a Meeting of the Operational Requirements Committee ... on 29th July 1936, to give further consideration to ... P.13/36
[68] ibid., DDOR to AMRD *et al*, 8.7.36, Appendix A

been reduced from 1,500 lbs to 1,000 lbs, but a range of 1,000 miles was retained.

The DTD explained to the committee that he had first looked at the increase in speed which could be obtained from the original case II by a reduced normal load and an increase in normal take-off from 500 to 600 yards. He said that "The object was to produce a smaller aeroplane". This case III did not give 300 mph. New design studies IV and V showed the improvement in speed over case III made possible by increased power. The DTD said that for these it was not necessary to take advantage of a longer take-off, although the landing distance needed to be increased to 600 yards. This was to cater for the higher wing-loading that was needed to get a higher cruising speed. Case V was a four-engined example which had been included as at the request of the AMRD (Freeman), but it was not as good as the twin Rolls-Royce Vulture engined Case IV.[69] (Note that the wing span of all these options was less than that of the B.9/32 Wellington.)

Verney said that from a normal 500 yard take-off case IV was estimated to have a cruising speed of 278 mph and a top speed of 320 mph. The Table of performance comparisons showed that with a 700 yard take-off the range would be 2,000 miles with a bomb load of 3,400 lbs, at a slightly reduced speed. It was hoped that catapult take-off would give 2,080 miles with 8,000 lbs or 3,000 miles with 4,200 lbs, with a further small reduction in speed. A reinforcing range of 2,800 miles was attainable from a 700 yard take-off.

Verney told the committee that although the Ministry did not intend to specify the type of engine, designers would be driven to use Vultures to get the required performance.[70] There is an interesting parallel in this

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[69] Minutes of 29th July 1936, para. 2
[70] ibid., para. 23

respect between the P.13/36 bomber and the Vulture engine and the F.7/30 fighter and the Goshawk. In neither case was use of a particular engine specified, but only one was available to designers to give the required performance. In both cases the engine was a failure, and with it the aircraft. The Vulture-engined Manchester was transformed into the Lancaster with Merlin engines, and the Supermarine F.7/30 sired the Spitfire, also with a Merlin engine.

It was explained to the committee that the limiting factor in design for speed was the tankage required for a range of 3,000 miles plus the usual allowance of ½ hour at full power for take-off and reserves. Verney had suggested at the first meeting on P.13/36 that if internal tankage was reduced to that for 2,000 miles it might be possible to get 300 mph, with the reinforcing range requirement of 3,000 miles without bombs met by detachable tanks.[71] After further consideration of this solution at the second meeting on P.13/36, it was decided that it would be premature to reduce the requirement to below 3,000 miles before it was seen what designers could do. But the reserve fuel requirement was reduced to that for ¼ hour at full power at sea level.[72]

To fulfil the role of torpedo bomber the bomb cell of P.13/36 was to be convertible to take four torpedoes.[73] However, Wing Commander W.S. Caster, representing Coastal Command on the Operational Requirements Committee, questioned the use of an aircraft of the proposed size as a torpedo bomber. Attacks on capital ships were expected to be costly, and Caster thought that the medium bomber would be too valuable to sacrifice in large numbers. It was decided to omit the specific requirement for torpedo carrying, but to say that, "designers should make

71 ibid., Minutes of 22nd June 1936, para.33

72 ibid., Minutes of 29th July 1936, paras. 3,4 and 28

73 ibid., Minutes of 22nd June 1936, para. 15

provision for carrying two torpedoes in a certain number of this class."[74]

Following the second committee meeting the DCAS (Courtney) reported to the CAS and sought his approval to proceed with new requirements based upon case IV. He said that after comparisons had been made of speed, bomb load and all-up-weight, he had reluctantly accepted requirements which would give a bomb load of only 1,000 lbs at a range of 1,000 miles from "poor or smallish aerodromes", but that, "Under maximum load conditions (with accelerated take-off) Case IV gives us a better performance than Case II". Courtney's remark illustrates the importance which the Air Staff attached to the catapult scheme. He explained that although the new medium bomber would have the same normal weight as the Vickers B.1/35 heavy bomber (the Warwick), it would be smaller and faster.[75]

Ellington approved the requirements, and they were circulated to aircraft firms on 24th August 1936.[76] Contracts for prototypes were awarded to Avro and Handley Page.

8.3 SPAN, TORPEDOES, TROOPS AND CANNON

The earlier sections of this chapter have described the Air Staff's intentions in the development of the two 1936 bomber specifications. These included reliance on assisted take-off to obtain very heavy operational loads, and the use of the medium bomber as a torpedo bomber. The literature largely overlooks the significance of these aims, but is critical of the limitation on span which was written into the requirements, and of a supposed troop carrying role. The eventual abandonment of assisted take-

74 ibid., Minutes of 29th July 1936, para. 39
75 PRO: AIR 2/2826, Medium Bomber Landplane Twin Engine Specn P13/36. Type Requirements, DCAS to CAS, 31.7.36
76 ibid., 16A, Appendix "B" to Specification P.13/36

off schemes is discussed in the next chapter as part of a discussion of the importance of airfield size for bomber development. This section discusses the significance of the span limit, the torpedo carrying requirement, and the actual requirement for personnel transport that was written into bomber requirements. It also examines the follow-up to Ellington's request that cannon armament should be considered for B.12/36.

8.3.1 Span Limitation

It will be remembered (chapter 7.2.1) that the practice of placing a limit on the span of RAF bombers had originated with Sir John Salmond's concern in 1931 about getting the aircraft designed to B.9/32 into "our sheds", and that it was only the size of Expeditionary Force hangars which was found to be relevant. In fact, when the Vickers Wellington was developed to B.9/32 with a span of 86 feet, this increase over the specification limit of 70 feet was accepted by the Air Ministry so as to get an improved performance.[77]

The idea that the reason for limiting the span of later bombers was the size of hangars persisted - even in the RAF. It has been shown in chapters 7.2.2.1 and 7.3.1 that Harris made scathing remarks about such a policy - if there was one.

The AHB narrative on the evolution of Bomber Command said the wing span of B.12/36 and P.13/36 was kept down "largely from considerations of hangar space", and many writers insist the 100 feet limit was related to the size of RAF hangar door openings. Mason asserts that 100 feet was "stated to be the maximum door width of current RAF hangars", even though he claims that a thorough search reveals that the door opening of the most widely used

[77] Goulding and Moyes, page 22

hangar was 126 feet.[78] Ellam agrees that most RAF hangars had door openings of more than 100 feet, but that "some older 'sheds'" had only 100 feet. He says that for this reason a reduction in the span of the Fairey Hendon (to B.19/27) from nearly 102 feet to 97 feet was considered, but not imposed.[79] In fact such a reduction in span was immediately rejected by Air Commodore R.P. Mills (DOSD) on the obvious grounds that the small clearance at each wing tip which would be achieved was "insufficient for taking big aircraft through a doorway".[80] His comment underlines the absurdity of claims that a 100 ft limit on span was placed with a view to getting a large aircraft into a hangar with a door opening of exactly the same size. It is also relevant that the then DCAS (Ludlow-Hewitt) commented that he had seen the Hendon put on a skate and pushed sideways into a hangar with a door opening of 85 feet. He called for more RAF experiments on this technique.[81]

In fact, when a limit of 100 feet was proposed for the new bombers in 1936, the reason then given was to stop them getting too large. As has been shown in chapter 4.4.3, this concern with size arose from the RAF's finding that the two large transports designed to specification C.16/28 were too unwieldy for ground handling. This concern was re-stated in the discussion of the B.1/35 specification.[82] For B.12/36 and P.13/36 it is clear hangar size was not an issue, for the opening paragraph of both requirements specified that, "Since it will be required to operate from bases anywhere in the world the aircraft must possess good facilities for maintenance in the open".[83,84] Specification

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78 Mason, British Bomber, page 313

79 Ellam, C., The British Heavy Bomber Aeroplane, lecture to the Newcomen Society, 11th December 1996, page 12

80 PRO: AIR 2/850, "Hendon" Fairey Twin-Engined Bomber Specn. 19/27 Type Requirements, DOSD to FO1, 13.2.33

81 ibid., DCAS to DOSD, 10.11.33 and 5.12.33

82 2/2820, 5A, February 1935, para.6

83 2/2629, 2A, para.1

84 2/2826, 23B, para.1

B.12/36 required that engines must be replaceable with ease and rapidity, "in the field".[85]

The limit on span of 100 feet imposed in specification B.12/36 is cited by Thetford,[86] Barnes,[87] Falconer,[88] and Goulding and Moyes[89] as the reason for the Short Stirling's poor performance. Of particular concern was its relatively low ceiling.

The geometrical parameter known as aspect ratio has a major influence on an aircraft's ceiling, and on its range. Aspect ratio is span squared divided by area, so as wing area is usually determined by landing weight and distance requirements, a limitation on span may prevent a designer obtaining an aspect ratio high enough for the required ceiling and range.

It is said by Barnes that Short Bros. wished to have a span of 112 feet for the Stirling but that, "Unfortunately, before ordering any prototypes, the Air Ministry stipulated that the span must not exceed 100 ft, in order to conform to existing hangar dimensions".[90] No doubt the design referred to by Barnes was that seen by the Operational Requirements branch before the Air Staff Requirement was issued, but if it was based upon a preview of the requirement, that included the 100 ft limit from its first draft. It was repeated in the final form which was sent to Short Bros. some months before prototypes were ordered.[91]

Short Bros. designed a wing with a span of 99 feet, aspect ratio 6.71. However, in his accepted design to the same specification, B.12/36, Mitchell of Supermarine's did not

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85 2/2629, 26A, para.33
86 Thetford, page 488
87 Barnes, Shorts, page 371
88 Falconer, J., Stirling at War, 1991, page 8
89 Goulding and Moyes, page 43
90 Barnes, Shorts, page 371
91 2/2629, [11A], DoC to Short Bros., 9th July 1936

think it necessary to fully exploit the limit set by the Ministry, for the span of that firm's Types 316-318 was initially but 93 feet, aspect ratio 6.97. This was later increased to 97 feet, aspect ratio 6.93.[92] Clearly Mitchell shared with Liptrot the view that it was not necessary to exploit the maximum span allowed to meet the specification, even though span squared is the critical parameter. Even the famed Lancaster had a wing span of only 102 feet.[93]

The major failing of the Stirling was a large increase in structure weight during design[94,95] - so much so that in 1940, when the question of additional fuel capacity for the Stirling was under consideration, it was said that this, "had no operational advantage since even with no bombs the weight of the aircraft plus normal military equipment exceeded the anticipated practicable operational all up weight".[96] If this was so the limit on span imposed in the specification was of little consequence.

8.3.2 Torpedo Carrying

A feature of the 1936 bomber specifications which had unlooked for repercussions was the requirement that the medium bomber P.13/36 should be capable of modification to carry torpedoes.

When tenders to specification P.13/36 had been received, it was found that provision to carry two 18 in. torpedoes (which were 18 feet long), without altering the main structure of the aircraft, or losing performance, was causing design difficulties. This led the DDOR (Oxland) to review the discussion on this issue which had taken

92 Andrews and Morgan, Supermarine, page 323
93 Thetford, page 68
94 2/2629, DDOR to DTD, 23.11.37
95 2/2899, AD/RDL to DGRD, 16.1.39, and 1A, 11.1.39
96 ibid., 13A, DOR to DD/RDA, 8.8.40

place at the two Operational Requirements Committee meetings on P.13/36.[97] He told the DCAS (Peirse) that the Coastal Command representative had given his C-in-C's view that the aircraft was too large and expensive for a torpedo bomber. Even so, the then DCAS (Courtney) had argued that whilst there was the possibility of a limitation on the numbers of first-line aircraft, it was desirable that every unit should be as effective in war as possible. As has been seen, a muted form of the torpedo carrying requirement was therefore included in the requirements.

Oxland recommended that as a dedicated torpedo bomber was now under development (B.10/36 - Bristol Beaufort), the torpedo requirement should be deleted from P.13/36. Alternatively, he said, provision could be made for a limited number of the aircraft to have larger bomb doors etc..

The Operations and Plans branches of the Air Staff did not agree that the torpedo requirement should be scraped. They advised Peirse that the Admiralty had yet to be persuaded that, "the 'B' bomb is in every way a more efficient weapon with which to attack ships", and that a torpedo bomber version of P.13/36 should be developed until the Admiralty was convinced otherwise.[98] (The "B" bomb was designed to be dropped in the path of a ship, sink, and then rise to strike the bottom of the ship as it passed over.[99,100])

This discussion was made redundant when the Operational Requirements branch announced that it had new information on the size of torpedoes, which meant the Avro P.13/36 could carry only one internally, and that in any case existing torpedoes could not be released at 150 mph from

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97 2/2826, 37A, P.13/36 - Torpedo Requirements, DDOR to DCAS, 22.4.37

98 ibid., DDOps (DDPlans concurring) to DCAS, 26.4.37

99 MacBean, pages 252-255

100 10/1430, Chapter V, para. 89

200 feet.[101] If this was relevant, the DCAS (Peirse) must have wondered how the idea of torpedo carrying for P.13/36 had arisen in the first place. It appears that the Operational Requirements branch had given no more thought to the operational problems of torpedo dropping than they were found to have given to catapult launching (chapter 9). Peirse decided that torpedo carrying would no longer be required of the P.13/36 bombers,[102] but by then designs were well advanced.

8.3.3 Troop Carrying

A common misconception regarding Air Ministry bomber requirements is that the Ministry always sought to combine bomber and troop transport requirements. This goes back to the early 1920s with the Vickers Virginia bomber and Victoria transport - which had the same wings.[103] Indeed, M. Smith appears to believe that it was the Victoria which was the bomber version.[104] Similarly, Mason maintains that the transport aircraft specification C.16/28 was, "primarily a bomber requirement in every respect but name".[105] But as shown in chapter 4.4.3, it was the aircraft industry which suggested that aircraft built to this specification might also serve as night bombers. Mason further claims that this,

> dual-role capability requirement was to be demanded in numerous heavy bomber Specifications during the coming decade, and thereby dominated the design of almost every RAF heavy bomber of the Second World War,[106]

He claims that the B.12/36 Stirling was, "to be able to carry 24 fully-armed troops".[107] Yet when Mason describes

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101 2/2826, OR1 to DCAS, 3.5.37
102 ibid., DCAS to DDOR, 26.5.37
103 Thetford, page 544
104 Smith, M., pages 32 and 230
105 Mason, British Bomber, page 228
106 ibid., page 228
107 ibid., page 314

the P.13/36 Halifax, he says that, "The fuselage was also much deeper than that of the Stirling, the secondary troop-carrying requirement probably dictating this."[108] Andrews and Morgan also claim accommodation for twenty-four armed troops was specified for B.12/36, in this case with reference to Supermarine's design.[109] Yet when Bomber Command officers inspected the mock-up - far from finding accommodation for fully armed troops - they were concerned as to whether there was adequate room for the crew. They reported that headroom throughout the fuselage was restricted, and that even the captain and navigator did not have room to stand.[110]

As discussed in chapter 7.3, the requirement that a heavy bomber should be designed so as to carry troops was indeed included in the first draft specification for the B.3/34 (Whitley). The Air Staff had been led to believe that this additional role could be obtained without a reduction in its performance as a bomber. It was dropped from the specification after discussions with industry, and after the DTD had admitted it would result in a loss of 10 mph in speed.

Specifications B.12/36 and P.13/36 did indeed ask that,

> Consideration is to be given in design for fitting a light removable form of seating for the maximum number of personnel that can be accommodated within the fuselage when the aircraft is being used for reinforcing Overseas Commands.[111,112]

Note that seating was to be fitted in the fuselage, not that the fuselage was to be designed to take seating. Clearly this provision referred to the need to transport RAF ground crew to RAF Overseas Commands - a concomitant of the introduction of a reinforcement range into bomber

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108 ibid., page 330

109 Andrews and Morgan, Supermarine, page 319

110 2/2629, 38B, Notes on Inspection by Bomber Command staff of the Mock-up of the Supermarine B.12/36, 5.10.37, para.7

111 ibid., 23A, para.9(xii)

112 2/2826, 23B, para.9(xii)

requirements. However, in 1939 Air Staff policy was that for the P.13/36 designs (Halifax and Manchester) this facility might be used to carry troops, albeit "'to special order only'".[113] In a lecture to the Higher Commanders' Course the point was made that these bombers, "will have all the necessary cabin space, lift capacity and range to fulfil the bomber transport primary role and its secondary functions as well", but it was noted that, "by reason of the multiplicity of internal installations in the fuselage the troops may not enjoy the same degree of comfort available in present types.".[114] Clearly a troop carrying requirement did not dominate - or even influence - the design of RAF bombers.

8.3.4 Cannon Armament for Bombers

It is noted in section 8.2 that in 1936 Ellington asked for 20mm cannon armament to be considered for the B.12/36, and that the Air Staff advised that this was neither possible nor necessary. Their reasoning was unsound, and the policy was soon reversed, but it was then too late to modify any of the designs to the 1936 bomber specifications, although attempts were made.

In chapter 6.2.2 it has been shown that when the cannon fighter (F.37/35) was devised, the replacement of eight 0.303in. machine guns by half that number of 20mm cannon was regarded as a major increase in armament. Yet in response to Ellington's request for consideration of cannon armament for bombers, Oxland considered only the replacement of machine guns by the same number of 20mm cannon. From this premise he argued that for a tail turret, the extra weight of cannon so far aft of the centre of gravity was unacceptable - hardly an insurmountable obstacle for aircraft which were yet to be

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113 20/96, FO1 to DDOps, 24.2.39

114 PRO: AIR 69/17, The Role of Bomber-Transport Aircraft, 3rd May 1939

designed. He added that recoil loads would give grave problems except for firing almost directly astern. For a two-gun midships turret, Oxland claimed that whilst the weight would be half that of the tail turret, the weight of the ammunition needed for an aircraft which would spend long periods over hostile territory would be unacceptable. It will be seen in chapter 9 that this self-contradictory argument was replaced in 1938 by the acceptance that it was worth replacing half the bomb load with ammunition if that made it more likely that the remainder would get through. For the nose turret, Oxland said that cannon would obstruct the bomb aimer, and would also be too heavy if beam fire was wanted. He then claimed that these difficulties could be avoided because a bomber did not need the extra range of a big gun.

This argument had been used in the Operation Requirements branch's review of fighter and bomber armament mentioned in chapter 6.2.[115] It was based upon the theory that when attacked from astern the effective range of a bomber's firing was considerably shortened as compared with that of the attacking fighter. This theory was irrelevant to defence against beam or frontal attacks, and therefore to midships and nose turrets. Nevertheless, Oxland claimed that it largely disposed of one of the two supposed advantages of 20mm guns. As regards the other advantage of cannon - an explosive shell - he said that the stage had not been reached "where this can be utilised effectively without severe disadvantages."[116] There had been no mention of such difficulties when he and Sorley had advocated cannon armament for RAF fighters in 1935 - it was then claimed that one hit from a 20mm shell would be decisive.[117]

Little more than a year after Oxland had argued against 20mm cannon armament for the B.12/36 he was advising Plans

115 5/1137, A.F.C./15,
116 2/2629, 10A, DDOR to DCAS, 19.6.36
117 5/1137, A.F.C./15, para.13

branch that bombers of the immediate future would need to be armed with 20mm guns (and later with 37-40mm guns).[118] This was confirmed in a review of bomber armament in June 1938.[119] Plans were made to fit 20mm cannon to Mark II versions of the Stirling, Halifax and Manchester,[120,121] but by then the centre of gravity issue was decisive because it had not been designed for in 1936. Experiments with a 20mm cannon midships turret for the Stirling and Halifax found that it was difficult to balance the aircraft even with the tail turret omitted entirely. The DD/RDA (W.S. Farren) explained to the Air Fighting Committee in 1940 that nevertheless this was the only way of having 20mm guns on existing bombers. He said that to have cannon in a tail turret, "they would have to start again from the beginning".[122]

8.4 THE CIRCLE COMPLETED

The outcome of the 1936 bomber specifications was remarkable. On the one hand, the prospect of catapult take-off led to a requirement for a relatively small heavy bomber to carry a very large bomb load or have a longer range than had been sought in earlier specifications. On the other hand, the desire for a multi-role high-speed medium bomber with a maximum range of 3,000 miles led to a relatively large aircraft of this type. Misleading interpretations of the Air Staff's intentions in 1936 most likely arise from a retrospective view of the development of the aircraft which were designed to meet these requirements. It transpired that the aircraft designed to the medium bomber specification (P.13/36) embodied the potential for development into more successful heavy bombers (Halifax and Manchester/Lancaster) than that

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118 9/82, 8A, note from DDOR, 26.8.37

119 9/77, The Gun Armament for Bombers, 2.6.38, para.33

120 PRO: AIR 2/3341, Question of Vulnerability of Fighters Against Existing Bombers, DDOR to DSD, 20.7.38

121 PRO: AIR 20/6, Priorities of Items of Armament Equipment, ACAS to DCAS, 21.12.38

122 5/1126, 21st Meeting, 5th April 1940, para. 61

designed to the heavy bomber specification, B.12/36 (Stirling). That this was possible can be traced to three technical features of the medium bomber specification - gross overloading with catapult take-off, fuel tankage for a range of 3,000 miles, and provision for the internal stowage of torpedoes.

Designs to specification P.13/36 needed to be stressed for catapulting at maximum overload, and to have internal stowage for the overload bomb and fuel load. In addition, provision had to be made for an unobstructed bomb bay if some of the aircraft were to serve as torpedo bombers. These additions to the normal requirements gave scope for the future development of the aircraft which followed from the specification after both torpedo carrying and catapult take-off had been abandoned. There was space for much larger bombs than were envisaged in 1936, and the potential for operation with large bomb loads using a longer conventional take-off run.

The first step towards the transformation of the intended medium to a heavy bomber came from Handley Page. Soon after commencing design to P.13/36 the company concluded that the aircraft would be very similar to their on-going design to B.1/35 - the "Americanised" B.3/34 heavy bomber specification. They asked the Air Ministry if they could stop work on their contract for B.1/35 and absorb it into their P.13/36 design.[123] This was agreed.[124]

Both the Handley Page and Avro P.13/36 bombers were initially designed to be powered by two Vulture engines as anticipated by Verney. But the Handley Page design was soon changed to four Merlins,[125] and, as will be seen in chapter 9, was thought to meet the P.13/36 maximum overload requirement without assisted take-off, albeit

123 PRO: AIR 2/1903, Proposals to Re-Design the Handley Page B1/35 as a P.13/36, Handley Page to AMSO and AMRD, 22nd September 1936
124 ibid., DTD to Director of Contracts, c.December 1936
125 2/2826, 45A, CAS to AMRD, DCAS, DoO, 24.7.37

with a long conventional take-off. Avro continued with the Vulture engine, but this proved a failure, and the P.13/36 Manchester was modified to the Lancaster, also with four Merlins.[126] Thus the Air Ministry's misplaced faith in the catapult scheme finished back where Liptrot's first estimates for a new heavy bomber had started - with bombers powered by four Merlins - albeit derived from requirements for a medium bomber.

126 PRO: AVIA 15/590, Manchester with Merlin XX Engines

9. OPERATIONAL REQUIREMENTS 1937-39

9.1 INTRODUCTION

The RAF's home defence role - the subject of this thesis - required bombers to attack an enemy's military and industrial infrastructure, and fighters to defend the United Kingdom against air attack. Throughout the Second World War these roles were largely fulfilled by aircraft derived from operational requirements which had been defined before the end of 1936. This is partly explained by the need of both the Air Ministry and the aircraft industry for a breathing space. Group Captain R.H.M.S. Saundby (who replaced Oxland as DDOR in January 1938) argued to the Assistant Chief of the Air Staff (AVM W.S. Douglas) in 1938 that,

> As a result of the introduction of the fast monoplane with relatively high wing loading in 1935, we have been obliged, during the last two years, in order to keep the Air Force up to date, to put out new requirements for every type of aircraft in service (...). This, of course, has resulted in an abnormal number of new specifications, and we have at present no less than seventeen types of aeroplane building which have not yet been tested, and in all but a few instances, not yet been flown.

Then after listing the types under development, he said that,

> It is clear that we cannot continue to issue specifications at the rate to which we have recently become accustomed. We must have a brief pause in order to try out the aircraft now building.[1]

It will be noticed below that many of the Air Staff Requirements which were planned in the late 1930s were delayed and redesignated.

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[1] 20/68, page 23, DDOR to ACAS, 23.9.38

As regards the significance of the tremendous advances that had been made in aviation in the 1930s, some thought that these favoured bombers, and others that they favoured fighters. It was, of course, expected that the development of RDF (radar) had improved the prospect of intercepting air attacks, but in "The Role of the RAF in National Defence" of July 1938, the Air Staff said that this must to some extent be conjectural, whereas "the advantages conferred on the bomber by its astonishing developments in speed are beyond dispute."[2]

On the other hand, at the same time Saundby, when writing upon the "Question of Vulnerability of fighters against existing bombers" , argued that,

> What has really altered the balance against the bomber is that the weight and performance of fighters is now such that the carrying of the small amount of armour necessary to protect the pilot and tanks can be arranged without difficulty.

Ludlow-Hewitt, as AOC-in-C Bomber Command, held similar views. He feared that his bombers would be helpless against fighters which had sufficient armour to make then invulnerable to machine-gun fire when attacking bombers from astern. Both Saundby and Ludlow-Hewitt saw that the solution was to armour a bomber, and so "make itself even more immune from fire than can the fighter"[3,4] - but this was all in the context of armour against machine guns.

The Air Staff argued that it was to meet such a development that they had specified the cannon fighter (F.37/35 - chapter 6.2.2), and sought a cannon armed turret fighter.[5] It was known that other nations were also planning cannon-armed fighters, and, as discussed in

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[2] PRO: AIR 8/244, Papers for Lord Chatfield, The Role of the RAF in National Defence, Air Staff, 5th July 1938

[3] 2/3341, DDOR to DSD, 20.7.38

[4] ibid., 2A, AOC-in-C to Air Ministry, 25th June 1936

[5] 8/214, DCAS to Dowding, 2nd December 1936

chapter 8.3.4, this led to plans to arm RAF bombers with similar weapons.

Technical developments in engines made feasible the development of high altitude bombers and fighters, as Peck had noted in his review of aircraft requirements undertaken in 1935 (chapter 3.3.2). Contrary to Postan's assertion that studies of "the high altitude aeroplane" were instigated by industry in 1939,[6] the Air Ministry undertook project studies and initiated experimental work at least two years earlier.

An Air Staff Requirement (B.25/37) for a four-engined bomber with a pressure cabin was drawn up in collaboration with the RAE in 1937,[7] the CAS gave instructions for high altitude studies to proceed in April 1938,[8] and plans to try a pressure cabin in a Wellington were also decided later that year.[9] In the war the need for high altitude aircraft was met by fitting pressure cabins to the Mosquito and Spitfire.

The most significant events in the late 1930s from the point of view of an analysis of operational requirements were the study of the economics of a bomber striking force - which resulted in the specification of an "Ideal Bomber", and parallel efforts to gain support for a "speed bomber". These are discussed in sections 9.3 and 9.4, but first the next section discusses plans for new fighters in the years immediately preceding the outbreak of war.

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[6] Postan, page 81

[7] PRO: AIR 2/2082, Consideration of Design of Experimental Heavy Bomber included as a Development Type in the 1937 Estimates. Specn. B25/37, DTD to RDA3, 18.6.37 and 3A, "Appendix "B" to Specification B.25/37

[8] 20/84, CAS to AMRD, 4.4.38

[9] PRO: AIR 2/3415, Development of Aircraft for Operating at High Altitudes, 2A, Notes of meeting ... on August 31st, 1938

9.2 FIGHTER DEVELOPMENT

In chapters 5 and 6 it has been shown that by the summer of 1935 Air Staff Requirements had been issued which led to the Hurricane, Spitfire and Defiant - the three first-line home defence fighters with which the RAF entered the war in 1939. In the years immediately preceding the outbreak of war, attempts were made to improve upon the 1935 single-seat fighter requirement (F.10/35) in terms of speed and firepower, and further efforts were made to develop a multi-seat turret fighter. None of these schemes was to supplant development of the Spitfire as the premier day interceptor fighter.[10] Their evolution throws no new light on the Air Staff's concept of air warfare, apart from continuing confusion over the best layout for a turret fighter.

9.2.1 <u>Hurricane and Spitfire Replacement</u>: F.18/37

In June 1937 the Air Staff opened discussions on a single-seat fighter to replace the Hurricane and Spitfire. They sought the views of the Research and Development (Aircraft) branch on possible performance levels of a fighter armed with twelve machine guns.[11]

Liptrot advised that a Napier Sabre engine of 1,920 hp could be expected to give a maximum speed of 405 mph, but he queried the Air Staff's proposed fuel allowances and landing distance. On fuel, Liptrot chided the Operational Requirements branch for using the old definition of 2/3rds power for endurance, whereas they should have calculated it "at maximum economic cruising power". (This change is noted in chapter 3.4.5.) He suggested that the fuel allowance for climb could be reduced as the fighter would reach its operating height in under five minutes, but on

[10] Postan, pages 126-127
[11] 2/2833, OR1(a) to RDA3, 3.6.37

the other hand, "would like to suggest" that the endurance of RAF fighters had got too low, with the result that they could not pursue bombers. He proposed an increase from one to two hours, although this would reduce the top speed to 400 mph.[12]

In regard to landing distance, Liptrot explained that if this could be increased to 775 yards, the top speed would rise to 415 mph at 15,000 feet and 428 mph at 19,000 feet.[13] He said that there was no need to mention take-off and climb in the requirements, as the use of very powerful engines and constant speed propellers ensured that these would be very good - wing loading would be determined by other considerations (e.g. landing distance).

A draft Air Staff Requirement[14] was drawn up for discussion by the Operational Requirements Committee on 29th November 1937. The Operational Requirements branch had taken heed of Liptrot's advice on fuel for take-off and climb, and also called for permanent tankage for 30% more fuel than needed to meet the normal endurance requirement. Dowding (C-in-C Fighter Command) said that this was not needed for home defence, but it was kept for possible overseas needs.[15] Air Staff policy on this issue was re-emphasised in 1938 when increasing the range of the RAF's fighters was considered. Saundby then explained that, "We have kept down the tactical range of our fighters to the minimum required for home defence in order to obtain maximum performance and fire power."[16]

Discussion at the committee meeting centred on two issues - twelve or eight guns, and top speed *versus* landing

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12 ibid., RDA3 to DDOR, 26.7.37

13 ibid., RDA3 to DDOR, 3.8.37

14 ibid., 8A

15 ibid., Minutes of the Operational Requirements Committee meeting held on 29th November 1937, para.57

16 PRO: AIR 2/3037, Investigation into the Possibility of Increasing the Range of Fighter Aircraft, DDOR to DDOps, 16.5.38

distance. Dowding expressed a preference for eight guns with more ammunition rather than twelve guns. But after consideration of the higher chance of a lethal hit from twelve guns, and the problem of stowage for more ammunition for eight, twelve guns were agreed, subject to an investigation of alternatives.[17] In this discussion a comment by DDOps underlined the RAF's expectation that it would be faced with defence against unescorted formations of bombers. He pointed out that,

> during the last war the single-seater pilot was nearly always exposed to attack by other single-seaters and would therefore be more liable to become excited than the home defence pilot who could attack possibly from a range at which the enemy could not hurt him. [pencil manuscript note, 'Will the Germans have fighter escorts?'][18]

The answer to the final query was presumably that they would not, for when referring to the latest fighters in production in May 1939, Saundby (then DOR) declared that,

> Generally speaking they are all intended for Home Defence i.e. the destruction of enemy bomber aircraft in circumstances in which they are unlikely to meet enemy fighter aircraft.[19]

At the Operational Requirements Committee discussion of F.18/37 Liptrot made his point that a landing distance of greater than 600 yards would be advantageous, but Dowding insisted that this would be dangerous for night flying from some fighter aerodromes. It was said that in any case 600 yards was the maximum permissible at some aerodromes. The reaction of the AMRD (Freeman) to these arguments was that,

> "aerodromes should be made larger. The size of aerodromes was a limiting factor in the development of better aircraft. We were handicapping ourselves in a way that no other nation would allow itself to be handicapped."[20]

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17 2/2833, Operational Requirements Committee Minutes, 29th November 1937, paras. 10-36

18 9/77, Operational Requirements Committee Minutes, 29th November 1937, para. 22

19 20/167, DOR to ACAS, 9.5.39

20 2/2833, Minutes, 29th November 1937, paras. 64-67

This problem also arose with respect to the Hurricane and Spitfire, for Fighter Command was concerned with their take-off with fixed pitch propellers. In July 1938 it was decided that 1,000 yard aerodromes would be adequate for these aircraft, but that their suitability for future fighter types with a variable pitch propeller - where landing would be the predominant problem - would have to be reconsidered.[21] It will be seen later that the performance of RAF bombers was also closely coupled with the size of airfields.

Freeman also queried the small difference between the performance called for in the new requirements and that then estimated for the Westland F.37/35 (the cannon fighter). He suggested that the new specification was not worth issuing unless the speed was raised to 420 mph.[22] In fact there was the possibility of getting a higher speed if a twin-engined fighter was accepted, but this was rejected by Dowding because there would inevitably be fewer larger fighters.[23] He thought that the Spitfire and Hurricane would be a match for the German aircraft coming into service.[24]

It was concluded that F.18/37 should proceed, but if it showed little advance over the Westland cannon fighter it could be abandoned.

Following the meeting the DCAS (Peirse) sought approval from the CAS to F.18/37 as a replacement for the Hurricane and Spitfire. He noted that although development of fixed and turret cannon fighters was proceeding concurrently, until these were proven they could not relax efforts to improve upon conventional (machine-gun armed) types.

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21 PRO: AIR 2/3351, Size of Fighter Aerodromes in relation to Take-off and Landing Run of Modern Fighter Aircraft, 1A, meeting on 11th July 1938

22 2/2833, Minutes, 29th November 1937, para. 109

23 ibid., Minutes, para. 37

24 ibid., Minutes, para. 44

Peirse said, "the F.18/37 Specification is designed to ensure this."[25]

Specification F.18/37 led to the Hawker Tornado/Typhoon, which were later to be armed with four 20mm cannon. Postan says that it, "was not quite the aircraft originally expected". As a fighter it was inferior to contemporary German aircraft and to later marks of the Spitfire. It was, however, successful as a ground attack aircraft[26] - a role that had been considered briefly by the Operational Requirements Committee in 1937.[27]

A new fixed-gun home defence fighter (F.6/39) was considered in 1939, but soon abandoned.[28] The only other pre-war fixed-gun fighter development was the Beaufighter. This was not in response to a new Air Staff Requirement, but was offered by Bristol as a cannon fighter which could be quickly developed by a redesign of the Beaufort torpedo bomber.[29] In 1940, when there was found to be a need for a long-range fighter to protect shipping, the Beaufighter was accepted for that role.[30]

9.2.2 Turret Fighters

In chapters 4 and 6 it is shown that there was a school of thought in the RAF which doubted the ability of fixed-gun fighters to break up enemy bomber formations. This had led to attempts to develop a type of fighter which could bring the firepower of a formation of fighters to bear simultaneously, and from many directions. The surviving result of these efforts was the Defiant, with a four

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25 ibid., DCAS to CAS, 20.12.37

26 Postan, page 127

27 2/2833, Minutes, 29th November 1937, paras. 7-8

28 PRO: AIR 2/3576, Fixed Gun Fighter Aircraft to Specification F6/39. Type requirements, 26A, Extract from Notes of Conference, 4th October 1939

29 PRO: AIR 2/3075, Beaufighter F.17/39. Type Requirements, DDOR to DDGP, 22.11.38

30 PRO: AIR 9/97 (no title), The Role and Requirements of a Long-Range Fighter, notes by Plans2, 13.3.40

machine-gun turret. Attempts to produce a cannon-armed turret fighter were pursued from 1936 to 1939, and these included resurrection of the front-turret and two-turret fighter types which have been discussed in chapter 6.3.

In May 1936, after plans had been made to replace the eight machine gun armament of F.10/35 by four 20mm cannon, the Operational Requirements branch suggested that the logical development was to replace the four machine guns of F.9/35 (Defiant) by a four 20mm cannon turret. This was the same dubious logic which had eliminated consideration of cannon armament for the 1936 bombers - surely replacing eight machine guns by four cannon implied replacing four by two. Moreover, it was now said that the ability to fire straight ahead was needed, and that this ruled out a single-engined aircraft, and possibly called for a nose turret.[31]

Thus the argument which had been used by Courtney in 1935 to justify cancellation of the "CAS" fighter type (F.22/33) and its replacement by the Defiant was turned on its head. Indeed, when the Operational Requirements Committee discussed the new turret fighter,[32] it was offered two options,[33] one of which was a reincarnation of the "CAS" type - a three seater with two twin-cannon turrets, one in the nose and the other amidships. This had been seen as the preferred layout.[34] The other option was a straightforward extension of the Defiant concept with a midships turret, but with four 20mm cannon and two engines so that it could fire straight ahead.[35] The committee decided to proceed with the two-seat single midships turret option. Unlike the Defiant, it was to have had one fixed forward-firing machine gun to answer Dowding's request for some means of engaging a single low-

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31 PRO: AIR 2/1798, Two Seater Fighter Landplane Specn. F11/37. Type Requirements, OR3 to DDOR, 20.5.36

32 9/77 Minutes of Operational Requirements Committee, 4th March 1937

33 ibid., DDOR to AMRD *et al*, 12.2.37, Draft Air Staff Requirements F.18/36, "A" and "B"

34 8/214, 7A, OR III to DCAS, 16.12.36

35 2/1798, OR3 to DDOR, 20.3.36

flying aircraft.[36] Why the forward firing turret did not meet this need was not discussed.

Dowding and Freeman questioned the feasibility of getting four 20mm cannon into a turret, and were told that a high-wing monoplane was envisaged with the turret merged into the top surface of the wing. It will be seen in section 9.3.3 that this arrangement was then taken up for the armament of the "Ideal Bomber".

After the committee meeting the designation of the new turret fighter was changed from F.18/36 to F.11/37,[37] and an Air Staff Requirement with that number was issued in May 1937.[38]

In 1938 the question arose as to the best proportion in Fighter Command of two-seat fighters to single-seat fighters, and this led to an Air Staff review of "Air Defence Fighter Tactics". It concluded that at the speeds then attainable by bombers a fixed-gun single-seat fighter could attack only from astern. In consequence it would be difficult to obtain surprise, the enemy would need only rear defence, and only one or two fighters could attack simultaneously. The review repeated the now familiar argument that, "The moveable gun fighter, by flying on a parallel course to the bomber, can attack it from any direction and so overcome all these disadvantages." It also argued that for "Air superiority fighting", where the aim was the destruction of opposing fighters and army cooperation aircraft, a moveable gun fighter could act defensively as well as offensively, and thus penetrate enemy territory and withdraw at will, whereas a single-seat fighter could not.[39]

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36 9/77, Minutes, 4th March 1937, paras. 21-26

37 2/1798, 21A, DOI to C-in-C Fighter Command, 16th April 1937

38 ibid., 26A, Specification No. F.11/37 Twin-Engined Two-Seater Fighter, Appendix "B"

39 PRO: AIR 2/2964, The Employment of 2-Seater and Single-Seater Fighters in a Home Defence War - Air Staff Note, 1A, 17.6.38

Perhaps it was this re-affirmation of confidence in turret fighters which led to yet another cannon-turret fighter proposal, for little progress had been made with the turret required for F.11/37.

Early in 1939 a new turret fighter requirement (F.2/38) was drawn up. The Air Staff now resurrected the need to fire at considerable angles of depression, and at first proposed to return to the Novel Fighter concept of a nose turret - with four 20mm cannon - albeit with limited arcs of fire.[40] However, this thought was overtaken by the suggestion that, "The upper turret of the B.1/39 may be suitable for this aircraft."[41] This implied a midships turret.

B.1/39 was the Ideal Bomber. Its armament was based upon the type of turret which had been envisaged for F.18/36 (F.11/37). Thus a turret development which initially arose from a fighter requirement, and was then to be specified for a bomber, was now proposed for a fighter. In fact it was found impossible to meet either need.

Project studies showed that the new turret fighter would be no better than that started in 1936 - now F.11/37.[42] After re-designation to F.26/39, the F.2/38 project was abandoned.[43] None of these post-1935 requirements led to a completed turret fighter.

9.3 THE IDEAL BOMBER

It has been shown in chapters 2,3 and 4 that the RAF had long sought a standard bomber which could serve for both day and night operations. This need was effectively met

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[40] PRO: AIR 2/3544, Turret Fighter Aircraft to Specification F26/39 Type Requirements, 1A, DDOR to DArmD, 3.1.39
[41] ibid., 2A, Air Staff Requirement for a Turret Fighter. Specification F.2/38
[42] ibid., RDT1 to OR1(a), 9.5.39
[43] ibid., 8A, 4.10.39

in 1934 when Ludlow-Hewitt successfully argued that it was by then possible for all bombers to operate by day and by night. The day bomber specification B.9/32 was amended to include full night flying equipment in 1935, and when the 1936 heavy and medium bombers were under discussion no time of day limitation on their operation was raised. The Air Staff then pursued a different approach to the concept of a standard bomber, where the aim was to obtain the maximum striking power from a given sum of money. The emergence of this concept has been noted in chapter 7 in connection with the Hart *versus* Sidestrand replacement issue, and in the discussions which led to abandonment of the light bomber class.

It was in July 1937 that the idea of a standard, all purpose, bomber began to crystalise within the Air Staff. The recently appointed DDPlans (Group Captain J.C. Slessor) put forward some general thoughts on the equipment of the RAF. He suggested two types of bomber - medium and heavy - both to have an operational range sufficient for war with Germany, and a reinforcing range to reach Egypt non-stop. These were no more than the principles which had lain behind the 1936 bomber specifications, B.12/36 and P.13/36. But when the DCAS (Peirse) saw Slessor's note he said that it did not answer his request for "an appreciation of the economical type of bomber aircraft for the Metropolitan Air Force."

Peirse said that it should not be assumed that a large aircraft was the obvious solution, for these might require special aerodromes of which only a few could be built. If so, the bomber force would be tied to these and present an easy target to an enemy, whereas a larger number of smaller aircraft could be dispersed over many normal airfields. He also feared that large bombers might be limited to night operations, and unable to undertake precision bombing.[44] These remarks by Peirse contradict claims that the RAF adopted a big bomber policy in 1936.

Peirse's concern with the inaccuracy of night bombing was confirmed by exercises in 1938 in which of forty-seven night raids only one was near enough to the target to be plotted - and that had an error of over a mile. Bomber Command attributed this, and poor results from earlier exercises, "to the extreme difficulty of finding and attacking an unilluminated target at night with high speed aircraft."[45] It needed two years of wartime operations for the implications of this conclusion to be accepted.[46]

Air Vice Marshal Freeman (AMRD) saw the DCAS's comment on the possible need for special aerodromes, and strangely made no mention of the catapult scheme fostered by his department, and which was fundamental to the 1936 bombers. Instead he offered a new solution to the take-off of heavily-loaded bombers. He suggested that a few airfields in the Eastern counties should be equipped with hard runways, and that these should be used for "bombing-up". Bombers would fly to them from their normal (grass) airfields with full fuel but no bombs, load bombs at the special airfields, and then continue to their targets.[47] This scheme was later to be rejected on the rather obvious grounds that it would introduce a vulnerable bottle-neck into bomber operations.[48]

Both Peirse and Freeman had raised a problem that was to dominate bomber development in the years immediately before the war, and which merits separate consideration.

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[44] 9/82, 2A, DCAS to DDPlans, 30.7.37

[45] 5/1132, Item 33, Air Staff Note on Bombing Policy, para.22, 2.2.38

[46] Webster and Frankland, Vol I, page 178; has a discussion of the Butt report on the accuracy of RAF night bombing

[47] 9/82, 3A, AMRD to DCAS, 4.8.37

[48] ibid., 15A, Minutes of a meeting to discuss heavy bombers and aerodrome surfaces, 5th October 1937, para. 7

9.3.1 Aerodrome Policy

The issue of the weight of aircraft which could operate from normal bomber airfields was fundamental to the bomber studies which Peirse and Slessor had set in train, and to the future of the bombers of the 1936 programme.

There seems to have been, at times, an amazing lack of continuity of policy on this subject. In 1936 the CAS (Ellington) had agreed the specification of a new heavy bomber (B.12/36) which was estimated to weigh over 30,000 lbs in normal operation, and nearly 50,000 lbs with maximum overload and catapult take-off.[49] Yet at a Secretary of State's Progress Meeting on 20th July 1937, when the possible need for concrete runways was discussed, he advised that it would be "strategically unsound" to place reliance on them, and that in consequence the all-up-weight of RAF aircraft should be limited to 30,000 lbs for take-off on grass.[50]

Against this background, Slessor responded to the DCAS's request for a study of the most economical size of bomber. He drafted a new paper, dated September 1937, entitled "Considerations Affecting the Design of Ideal Bomber Aircraft for Metropolitan Air Force". In this he examined the best way of achieving the maximum bomb lift for an expenditure of £20 million. This paper, and its re-drafts, became known in the Air Ministry as the "Ideal Bomber" paper, and are referred to as such hereafter.

Slessor explained that although his terms of reference were "limited to consideration of the most economical size of bomber aircraft for the Metropolitan Air Force", he thought it necessary to take a long view. He said that although Germany was then seen as the enemy, in ten years time it might be Russia, or Japan, or Italy. Therefore

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[49] 9/77, Minutes of the Operational Requirements Committee, 27th May 1936, para.2
[50] PRO: AIR 6/30, 90th Secretary of State's Progress Meeting, 20th July 1937, page 4

the RAF must be prepared to get its bombers to anywhere in the world from the United Kingdom - "and that means adequate reinforcement range." Moreover, they must be able to operate from locally available aerodromes - a consideration which he said, "may limit the size and weight to which we can economically go."

Slessor then examined four examples, which he compared on the basis that, "the true criterion of cost of a bomber force should be the cost per ton delivered at the target.". The detail of these examples was overtaken in the final version of the paper; suffice to say here that he concluded that a bomber with a maximum bomb load of 10,000 lbs was the most economical. However, Slessor feared that a bomber of this size might need hard runways, and that Freeman's "bombing-up" scheme might have to be considered.[51]

These fears were justified. Slessor was advised that his proposed bomber would be similar to the B.12/36 which had been ordered in the previous year. It would need a take-off on grass of 1,400 yards, or of 900 yards on concrete. The B.12/36 bomber was, of course, planned to be catapulted when highly overloaded - its normal bomb load was 2,000 lbs from a take-off on grass of 500 yards, and the maximum conventional take-off then considered feasible was 700 yards. Slessor was also advised that bombers needed to be armed with 20mm cannon (as noted in chapter 8), and that to get a high speed the bomber must be as small and clean as possible.[52]

Following this advice, Slessor sent his draft paper to other branches of the Air Staff with the comment that it had, "a possibly dangerous bias towards the big aeroplane,

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[51] 9/82, 9B, Considerations Affecting the Design of the Ideal Bomber Aircraft for the Metropolitan Air Force, DDPlans to DDOps, 2.9.37
[52] ibid., 8A, from DDOR, 26.8.37

and that its disadvantages may not have been fairly brought out."[53]

The tentative conclusion that the RAF's standard bomber should be relatively large re-opened the question of what was the heaviest weight acceptable to normal airfields. In September 1937 Slessor explained to the DCAS that,

> In the course of the appreciation now in the course of preparation on the subject of the Ideal Bomber, there is one point which is of such fundamental importance, and on which there appears to be so much difference of opinion, that I think it should be cleared up at once before we go any further. The point is that of the heaviest weight on the wheel that can be accepted for normal aerodromes, i.e., without concrete or tarmac tracks or runways

He suggested that a survey should be made of how other countries dealt with this problem, and a meeting called to consider RAF policy.[54] The Air Staff appear to have been unaware of a meeting on the same subject held in the previous June by the Director of Organisation (AVM W.L. Welsh). This concluded that runways were required at aerodromes with poor surfaces, and that fighter aerodromes should be "tracked" to ensure all-weather operation. (Tracking was the use of wire netting over grass.[55]) It also noted that Imperial Airways operated the Ensign (a four-engined airliner) at 45,000 lbs from grass airfields.[56]

A survey of the practice of foreign air forces showed that Germany had no hard runways, although it operated aircraft up to 44,000 lbs.[57] The American[58] and Russian[59] air forces were found to have some concrete runways. At the meeting

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[53] ibid., 9A, DDPlans to DDOR and DDOps, 2.9.37
[54] ibid., 11A, DDPlans to DCAS 25.9.37
[55] Ryan, R., "From Grass to Concrete", Aerospace Historian, Vol 21 (1974), No.4
[56] PRO: AIR 2/2067, Design of Aerodromes - Future Requirements - Policy (Runways), Notes of meeting on Aerodromes - Future Requirements in Design, 16th June 1937
[57] 9/82, 11C, AI3c to DDI, 30.9.37
[58] 82 ibid., 11E, AI2d to DDI, 4.10.37
[59] 82 ibid., 11D, AI2b to DDI, 1.10.37

initiated by Slessor, Colonel J.F. Turner (Director of Works) explained that these countries had little choice because their continental climate militated against good grass.[60] Turner also advised that it was rapid taxying and sudden braked turns that damaged grass surfaces more than take-off and landing. (Higham claims that it was not until 1943 that this problem was discovered.[61])

Experiments on taxying and braking could be made by overloading an existing aircraft, and these were put in hand to determine the tyre pressure that was acceptable on grass airfields.[62] The tests were made in 1938, and showed that there need be no limit to the weight of aircraft using grass aerodromes if tyre pressures were below 40 lbs/sq.in. It was noted that, "All R.A.F. aerodromes are being made to withstand these tyre pressures."[63]

This result was not available at the discussion of aerodrome surfaces in October 1937, and it was then decided that, because of the great expense which a complete system of hard runways would entail, it was undesirable to commit the RAF to it for bomber aerodromes. Policy would be to use grass airfields, with take-off at intermediate loads and landing at light loads.[64]

The question then arose as to how to take-off under overload conditions. Turner mentioned two rail-launching systems; one was an unassisted rail-track scheme proposed by the RAE, and the other (presumably) the catapult scheme. He also drew attention to a power-assisted rail-track system patented by Captain F.T. Courtney (a private

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60 82 ibid., 15A, para. 5.

61 Higham, R., "Airfields, technology and the realities of war", Kansas State University, pamphlet held by Royal Aeronautical Society, November 1990

62 9/82, 15A, para.3

63 ibid., 20A, The Suitability of Grass Aerodromes for the Operations of Heavy Bombers, Air Staff, 29.10.38

64 ibid., 15A, para.6

inventor). It was agreed that investigation of these systems should continue.[65]

Some type of assisted take-off scheme was essential if the maximum requirements for range and bomb load sought for the 1936 bombers, let alone those considered for the Ideal Bomber, were to be achieved. In January 1938 Slessor became concerned with the lack of information on such schemes. He wrote to the DCAS (Peirse) to express concern that he had heard of no progress on either the catapult project or the "Courtney rail launching scheme". He said,

> The advantages which our air striking force, once it is equipped with B.12/36 and P.13/36 aircraft, will derive from assisted launching devices are literally enormous. I can think of no field in which we can do more to increase our striking strength and thus make up for such difficulties as slow production of aircraft and restriction of our first line strength.

Slessor gave figures which compared the performance of these aircraft with a 700 yard take-off with that obtained from assisted take-off, and said that "You will see that the assisted take-off increases the bomb load threefold for the same range."[66]

Peirse shared Slessor's concern, and asked the Research and Development Department for a progress report on assisted take-off schemes. He pointed out that unless assisted take-off was possible for the Manchester (the Avro design to P.13/36) and for the B.12/36, the striking force would be considerably restricted.[67]

The AMRD (Freeman) replied that one catapult was being constructed and should be completed in 1940. It would be capable of launching a 60,000 lbs aircraft at 110 mph every three minutes, and would cost £106,000. He said that there was another assisted take-off scheme, known as

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[65] ibid., 15A, para.7

[66] PRO: AIR 20/14, Assisted Take-Offs, DDPlans to DCAS, 5.1.38

[67] ibid., DCAS to AMRD, 11.1.38

the Directional Control Take-off System. With this the bomber was secured to a truck and accelerated under its own power along a railway track. Freeman said that this scheme was an improvement over that proposed by Captain Courtney, and might be ready in 1939.[68]

Slessor's comment on the railway scheme was that he believed that only theoretical work had been done on it, and that in any case the US Navy had looked at something similar and turned it down because of the great length of track required as no extra power was provided.[69]

It appears that although the Air Staff had been persuaded by the Directorate of Technical Development to pin great hopes on assisted take-off, and had specified aircraft to take advantage of it, no urgency had been placed on its development, and little thought had been given to its operational use. When this sorry story came to the notice of the DDOR (Saundby), his comments were those which should surely have been made in 1936. He said that whilst one catapult per aerodrome might suffice (but only if formation flying was not required), it would increase the cost of an aerodrome by 25%. Saundby had no doubt that bomber aerodromes could be increased greatly in size for less than the cost of a catapult. He thought that the railway scheme might be cheaper than a catapult, but he shared Slessor's doubts about its effectiveness. Saundby advised the DCAS (Peirse) that,

> The cheapest and safest solution of the problem of taking-off heavily loaded bombers appears to me to lie in increasing the size of natural aerodromes. By doing so, we shall at the same time contribute towards the solution of the fog landing problem, and give ourselves more room to disperse our aircraft on the ground.[70]

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68 ibid., AMRD to DCAS, 18.1.38
69 ibid., DDPlans to DCAS, 26.1.38
70 ibid., DDOR to DCAS, 28.1.38

Peirse's reaction was, "The more I see of this the more convinced I am that our bombers must be capable of getting off grass aerodromes, under overload conditions, under their own power."[71]

Where did this leave the bombers which had been specified to exploit catapult take-off?

Peirse believed that the B.12/36 designs (Supermarine and Short Bros.), and the Handley Page P.13/36, could all take-off with overload in 600-700 yards, but that, "The Avro 13/36 has been designed for assisted take off & for this reason I am against producing this type in quantity - Can you confirm?" Fortunately for the future development of the Avro Lancaster, when Saundby reviewed the position he found that Peirse was wrong in his belief that the Avro P.13/36 was the odd one out - none of the current bomber designs could meet their planned maximum overload with a take-off of 700 yards.

Saundby found that the catapult requirement for the Handley Page P.13/36 had been cancelled, "because the firm stated, and R.D.A.3 [Liptrot] confirmed, that this aircraft with four Merlins would take-off in less than 700 yards at maximum loading. This is now stated to be 730 yards." He continued, "Neither of the two 12/36 designs can take-off at <u>maximum load unassisted</u> within 700 yds". It was estimated that they could attain a range of 2,000 miles with a bomb load of 4,000 lbs with a take-off of less than 700 yards[72] - this was the original requirement with a 700 yard take-off.

The issue of take-off at high weights was effectively settled by the development of larger airfields - a step noted in chapter 5.3.2. with respect to the cannon fighter of 1935, and in D.J. Smith's <u>Britain's Military Airfields</u>

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71 ibid., DCAS to DDOR and Plans, 4.2.38
72 ibid., DDOR to DCAS and ACAS, 25.2.38

1939-45.[73] In December 1938 the Secretary of State for Air was advised that if variable-pitch airscrews and flaps were used, the "Aircraft which were originally expected to need assisted take-off in overload conditions will now take-off within the 1,000 yds. limit."[74]

As four years earlier the then DTD (Cave) had assumed the use of these devices when assessing the performance of the B.3/34 heavy bomber (chapter 7.3.1), it is surprising that so much emphasis had been given to assisted take-off schemes in the intervening years. The answer probably lies in the RAF Expansion Schemes between 1934 and 1938, for these implied the need for many new airfields, and they would be built to the new standards.

A 1,000 yard take-off was used in the next stage of the Ideal Bomber project. Nevertheless, research on assisted take-off schemes continued.[75] These included variations on the railway launching scheme - with extra power from rockets, or from a large flywheel, or from dropping a large weight down a well. But when these schemes were reviewed in 1940, Bomber Command declared that concrete runways were essential - both for landing as well as for take-off. The then DDOR (Group Captain H.V. Rowley) concluded that assisted take-off was no longer an urgent problem![76]

During the war new airfields for heavy bombers were built with hard runways of up to 2,000 yards in length.[77] As noted in chapter 8, the aircraft derived from the 1936 bomber requirements were then able to benefit from their inbuilt capacity to take the very high loads which had originally been specified to exploit catapult take-off.

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[73] Smith, D.J., Britain's Military Airfields 1939-45, 1989, page 12
[74] PRO: AVIA 10/17, (no title), DDRD to SoS, 14th December 1938
[75] PRO: AIR 20/385, Methods of Assisted Take Off of Aircraft, OR1 to DDOR, 18.10.38
[76] PRO: AIR 20/387, Assisted Take-Off of Aircraft, A219, DDOR to DOR, 29.10.40
[77] Halpenny, B.B., Action Stations, 1981 and 1991, page 10

9.3.2 Options for a Standard Bomber

The need to bring the theoretical consideration of a standard bomber to a conclusion was hastened following a meeting of the Operational Requirements Committee on 24th November 1937 to discuss a new medium bomber project, B.17/37.[78] This requirement was deferred pending discussion of the Ideal Bomber.[79] It reappeared in most respects as a bomber/reconnaisance aircraft project (18/38) which was initiated by the Directorate of Technical Development.[80] This was for "a bomber of composite construction capable of being manufactured by trades, other than the highly specialised trade in the aeroplane industry". It was believed that in this way, "we can make an attractive emergency aeroplane with a good performance".[81] But when the Armstrong Whitworth Albemarle (which did not serve as a bomber) was produced to this specification in 1941 it was disowned by the Air Staff, who said that it did not meet any Air Staff requirement, nor was there any clear definition of its operational employment.[82]

Wing Commander A. Collier of the Plans branch of the Air Staff had attended the Operational Requirements Committee meeting on B.17/37. In his opinion, "The further the discussion of the B.17/37 continued, the more it became apparent that little good could come out of it". He urged completion of the Ideal Bomber paper as the basis for a discussion of bomber policy.[83] The Air Staff took heed of Collier's advice, and a new version of the Ideal Bomber

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[78] 9/77, Minutes of meeting on B.17/37, 24th November 1937

[79] ibid., para. 67

[80] PRO: AIR 2/3229, Type Requirements for Bomber Reconnaissance A/C. For Rapid Construction, 15B, Appendix B to Specification No. 18/38

[81] ibid., DDTD to AMRD, 24.3.38

[82] PRO: AIR 2/3352, 'Albemarle' Bomber Aircraft Armstrong Whitworth Specification B/18/38. Type Requirements, 25A, DOR to ACAS(T), 20.8.41

[83] 9/82, Plans to DDPlans, 24.11.37

paper was produced for consideration by the Bombing Committee.

It is of interest that up to this stage investigation of a standard bomber had been led by Plans branch of the Air Staff, and that bomber policy was seen as the province of the Bombing Committee, not of the Operational Requirements Committee. It will be seen that when the project was taken over by the Operational Requirements branch after recommendations from the Bombing Committee, there was a change in approach.

Despite the shadow cast over big bombers by the discussions on airfield policy, very large bombers were included amongst the five options, A-E, which were offered in the new paper.[84] (Liptrot saw these as "his family of bombers"[85]). With a normal take-off (now increased from the 500 yards used in the 1936 bomber studies to 700 yards), the options considered ranged from a normal bomb load of 1,000 lbs with an all-up-weight of 18,000 lbs, to a bomb load of 18,000 lbs with an all-up-weight of 160,000 lbs.[86] In all cases an operational still air range of 2,000 miles (to give a radius of action of 750 miles) was specified, with a reinforcing range at most economical speed of 2,750 miles (this determined the required fuel tank capacity[87]). In each case an overload take-off of 1,000 yards was also examined, and this allowed bomb loads of a nominal 4,000 lbs for case A, up to 44,000 lbs for case E.

The basis of the paper was as before - the total bomb lift which could be obtained for £20 million. This determined the number of aircraft of each type which could be built and hence the total bomb lift which each type could

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[84] ibid., 19A, Considerations Affecting the Design of the Ideal Bomber Aircraft for the Royal Air Force, Air Staff, March 1938

[85] PRO: AVIA 10/15, Ideal Bomber (Freeman's papers), RDA3 to AMRD, 20.4.38

[86] 9/82, 19A, Appendix A

[87] ibid., 19A, Appendix C

deliver. Total bomb lift was compared at both normal and overload take-off. With a normal take-off there was a steady increase in bomb lift with increase in aircraft size, i.e., a smaller number of larger aircraft was more than offset by their higher bomb load. But at maximum overload the Table showed only a modest advantage from increasing size above case B,[88] which was an aircraft of 35,000 lbs all-up-weight in normal operation. In fact, on the data given, the smallest example (case A) was actually slightly better than case B in terms of bomb-lift for £20 million. But the paper did not show this, because case A was rejected on the grounds that an acceptable cruising speed could be achieved only by restricting the size of its fuselage. In consequence it could not stow its otherwise attainable maximum bomb load of 4,000 lbs.

It was argued that high speed was desirable to make interception more difficult, to reduce the time over enemy territory, and to hinder anti-aircraft fire. The five bombers considered were estimated to have maximum cruising speeds with a normal take-off of 265 mph for case A up to 280 mph for case D. These would be reduced by about 5 mph at maximum overload. As compared with the 1936 bomber specifications, these speeds were considerably higher than that sought for the heavy bomber, B.12/36, but little different from the final choice for P.13/36. It will be seen that as discussion of the Ideal Bomber progressed, it was speed which became the dominant consideration, the political justification of large bombers, and ultimately the death of the Ideal Bomber project.

Nevertheless, both in the paper and later, it was not accepted that speed alone could provide adequate defence. Whilst it was accepted that an unarmed fast bomber might evade fighters in poor weather and darkness, it was thought that they could not be expected to penetrate a

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[88] This result arose because the assumed ratio between maximum and normal bomb load reduced with increasing size of aircraft.

modern defensive system in daylight. It followed that the Ideal Bomber would need heavy armament, and possibly armour.

This was a key conclusion, for the paper cited experience of the Spanish Civil War,[89] and from RAF experiments, which showed that high performance bombers could be attacked only from astern. This emphasised the need for a tail turret - another reason for the rejection of the smallest option - because the larger the bomber the less detrimental to performance would be a tail turret. Similarly, it was said that only a relatively large aircraft could mount an under turret to defend against attacks from below by turret fighters.[90]

The paper noted that fighters armed with guns firing explosive shells were being developed, (a number of cannon armed fighters were displayed at the Paris Exhibition 1938[91]), and that if a bomber was to carry similar weapons it would need to be at least as big as case B. At that size it would also be feasible to carry armour, at least against 0.303 in. ammunition. On the other hand, aircraft as large as cases D and E would present a large target, but give no significant benefit in fire power or speed over B or C. Furthermore, it was believed that ramming might be a worthwhile (cost effective) defence against bombers larger then type B. (For some years the RAF had itself considered ramming as a possible defence against bombers.[92])

In regard to "requirements on the ground", the paper noted that whilst it was obvious that fewer aircraft would need less overall maintenance effort, the probable need for hard runways arose with very large aircraft. It was

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89 PRO: AIR 2/3233, Use of Armour Plating for - Foreign Aircraft, 1B, report from the Rolls-Royce Paris agent, 16.12.37

90 9/82, 19A, paras. 28-30

91 Clinton, A.C., "The Trend of Development in Aircraft, some impressions of the Paris Exhibition 1938", JRUSI Vol 84 (1939), page 144

92 20/68, OR2 to DDOR, 29.10.38

suggested that all cases up to C (normal all-up-weight 56,000 lb) could use a normal (grass) airfield.

The paper concluded that case B was much to be preferred to A, and that case C did not give a substantial improvement over B. Cases D and E were rejected as too large. An aircraft of about the size of case B was recommended.[93]

Postan refers to contributions to the Air Staff's Ideal Bomber study from industry, and particularly from Barnes Wallis of Vickers,[94] but the timing is wrong. It was after the Ideal Bomber paper had been written (it was sent to Freeman on 27th January 1938[95]) that the DCAS (Peirse) suggested that Freeman might show it to some firms to get their views.[96] Freeman replied (unofficially) that he agreed that it was unreasonable to go further with consulting the best designers, and that in view of production commitments there was time to do so. But he added that, "In saying this I realize we must also take into account that design staffs are now awaiting work."[97]

All but Vickers agreed with Liptrot's estimates.[98,99] Vickers comments were followed by a paper by Wallis dated November 1938[100] - some months after the Ideal Bomber issue had been discussed by both the Bombing and Operational Requirements Committees.

Postan may have confused Freeman's approach to firms on that Ideal Bomber project with a proposal from Wallis for a six-engined bomber in 1936. This advocated a layout

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93 9/82, 19A, para. 78
94 Postan, page 79
95 AVIA 10/15, DDOR to AMRD, 27.1.38
96 ibid., DDOR to AMRD, 2.2.38
97 PRO: AIR 2/3239, Considerations Affecting the Design of Ideal Bomber Aircraft for RAF, 11A, Freeman to Peirse, 8.2.38
98 AVIA 10/15, RDA3 to AMRD, 20.4.38
99 ibid., RDA3 to PS to AMRD, 10.5.38
100 PRO: AIR 20/364, Bomber Aircraft: The determination of the Most Economical Size - Vickers Armstrong Ltd.

where a low structure weight was obtained by distributing all engine, fuel and bomb loads across the wing span. The Air Staff were aware that this was not a new idea, and that it could be achieved only with a large aircraft.[101] (It would also have a restricted size of bomb cell, although the significance of this was not then appreciated.) Assessment of Vickers' proposal was suspended in 1937 until the Ideal Bomber appreciation was completed.[102]

9.3.3 Bombing and Operational Requirements Committee Discussions

The Ideal Bomber paper was the only item on the Agenda of the Bombing Committee at its meeting on 4th May 1938.[103] The Chairman (Peirse, DCAS) explained that the committee was to decide the operational requirements, with a view to the production of a specification, of what had been termed the "Ideal Bomber". He said that,

> By that was meant the ordinary standard bomber for the Royal Air Force; and the Committee's opinion was required on the extent to which it would be possible to standardise, for mass production for the Bomber Force at home and abroad, one type of bomber aircraft.

The basic assumptions of the Air Staff's paper were accepted. An important recommendation which arose from the committee meeting was that the new bomber must be designed around its turrets - no doubt a reaction to the consequences of the failure to provide for 20mm cannon armament in the 1936 bomber specifications.

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101 PRO: AIR 2/2673, Proposal by Vickers Ltd. for a Special Six-engined Heavy Bomber, 1A, RDA3 to AMRD, 21.7.36

102 ibid., DDOR to ACAS, 26.9.38

103 PRO: AIR 2/2958, Bomber landplane to Spec. No. B1/39. Type Requirements., 1A, Minutes of the 17th meeting of the Bombing Committee, May 4th 1938

The committee considered whether or not formation flying would be necessary. Contrary to previous RAF doctrine, which had stressed the defensive power of bombers in formation - both of its own and of an enemy's, the Ideal Bomber was to be so well armed as to be able to defend itself. It would then be able to avoid anti-aircraft fire by manoeuvring. Saundby (DDOR) admitted that this point had been over-emphasised, and he agreed with ACM Sir Edgar Ludlow-Hewitt (AOC-in-C, Bomber Command), that there might be occasions when formation flying would be desirable.[104] These points clearly referred to operation in daylight, but it was agreed that provision should also be made for night bombing.[105]

In his summing up of the Bombing Committee's discussion, Peirse said that they had outlined the minimum requirements of a standard bomber which would fulfil the main functions of Bomber Command. The aircraft to meet these requirements might be between cases A and B, but "if adequate defence were to be provided for, Type 'B' might be too small."[106]

Type B as put before the Bombing Committee was specified to have a normal bomb load of 2,500 lbs, coupled with an operational range of 2,000 miles at 270 mph. With a take-off of 1,000 yards the overload bomb capacity was 8,000 lbs.[107] Apart from an armament of 20mm cannon, this specification was little different from that of the medium bomber P.13/36 (with the same 700 yard take-off), a comparison which Collier[108] had noticed when he had been given a preview of the Ideal Bomber paper by Slessor.[109]

Following the meeting of the Bombing Committee, the Operational Requirements branch of the Air Staff wrote to

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104 ibid., paras. Q.7
105 ibid., paras. Q.6
106 ibid., para. 111
107 9/82, 19A, Appendix A
108 2/3239, 3A, Collier to DDPlans, 22.1.38
109 ibid., manuscript note between 3A and 4A

Liptrot to say that they were drawing up operational requirements based upon the decisions by the committee, and asked for performance estimates for the range of cases in the Ideal Bomber paper. They stressed the need for high speed, and for formidable armament - with front, upper, lower and tail turrets, each with two 20mm cannon.[110] This request was soon overtaken by a decision to move away from the analysis of the Ideal Bomber as discussed by the Bombing Committee - whose decisions were supposedly being implemented.

Liptrot was told to limit his investigation to maximum bomb loads of 8,000 lbs and 12,000 lbs respectively. The reinforcing range was increased to 3,500 miles, and was to be at a higher speed than previously specified. The 12,000 lbs case, which became the Air Staff Requirement, was to have two four-cannon turrets, one above and one below the aircraft's centre of gravity. The operational range of 2,000 miles with maximum bomb load was required from a take-off of 900 yds rather than the 1,000 yds previously assumed. Self-sealing or armoured fuel tanks were specified.[111]

The new armament arrangement arose from general study of bomber armament following a request from Ludlow-Hewitt. It was argued that for aerodynamic reasons a bomber could not have turrets with more that one cannon at the front, two in the tail, and none underneath. An under turret was regarded as essential for defence against turret fighters, which - in Air Staff theory - could attack bombers from any direction, as explained in chapter 6 and earlier in this chapter. It was said that, "We know little of foreign developments regarding turreted fighters but we

[110] 2/2958, OR1(a) to RDA3, 14.7.38
[111] ibid., OR1(a) to RDA3, 25.7.38

must give potential enemies credit for initiative equal to our own."[112]

The proposed central turrets were said to give the additional advantage of allowing the bomber to carry and expend a very large amount of ammunition without affecting its stability. Then, as the DDOR later explained to a sub-committee set up to consider armament for the Ideal Bomber,

> If, in clear weather, the B.19/38 should be required to operate in formation it will be possible to dispose a proportion of aeroplanes in certain places in the formation which will carry a light bomb load or even no bomb load at all, but will carry the equivalent weight of ammunition and so will be used primarily for the defence of the formation.

This "escort bomber" tactic has been discussed in chapter 2.3.2. Unfortunately, Saundby was also obliged to tell the sub-committee that,

> while we had the authority of the Bombing Committee to 'build the B.19/38 around its turrets' we had no turrets available at the present time to form the foundation of our requirements and consequently it was necessary to develop the turrets concurrently with the aeroplane.[113]

The requirements prescribed for the Ideal Bomber were taken further following a meeting of the Operational Requirements branch with the DCAS and ACAS in July 1938.[114,115] On seeing the new Air Staff Requirement, Wing Commander L.F. Pendred (FO2) commented that although this was to be based on the recommendations of the Bombing Committee, "It seems, however, that in most respects it is an improvement on these recommendations." He observed that the cruising speed of 300 mph which was now called

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112 PRO: AIR 14/380, Notes of Air Staff Requirements for a Bomber Landplane - Spn B19/38, The Gun Arrangements for Bombers, Sholto Douglas to Ludlow-Hewitt, 9th August 1938

113 2/2958, 14A, Minutes of the First Meeting of the Sub-Committee Formed to Consider the Armament Requirements of the B.19/38, 22nd August 1938

114 ibid., minute by Wigglesworth, 6.8.38

115 ibid., 5A, Air Staff Requirements for a Bomber Landplane. Specification No. B.19/38,

for implied a top speed of about 350 mph - which was faster than the latest "Messer Schmit" (sic) fighter.[116] It will be seen that this was the last straw which broke the back of the Ideal Bomber project, but at the time it was thought that the bombers being designed to the 1936 specifications would have a maximum speed of nearly 330 mph.[117,118]

The revised Air Staff Requirement (B.19/38)[119] was discussed by the Operational Requirements Committee on the 11th August 1938. Many of those present had also attended the Bombing Committee's discussion of the Ideal Bomber. Nevertheless, the replacement of that committee's recommendation to pursue a bomber of about the size of case B by requirements which implied an aircraft much larger than case C was not queried. The draft requirements were largely accepted.[120]

There was some discussion of range. Ludlow-Hewitt suggested that only a small proportion of raids would be required to penetrate long distances, "as the risk involved in flying over so many miles of defended country would make it an uneconomical proposition." Such doubts have been noted in chapters 4.2.2.3 and 6.1, but were not discussed further at the committee meeting. It was said that 2,000 miles was needed to attack Berlin, and that in any case fuel tankage was determined by the range required for reinforcing purposes. Furthermore, now that Austria had become a province of Germany, and as Vienna was an important strategic target, it was suggested that an operational range of more than 2,000 miles might be necessary.[121]

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116 PRO: AIR 20/35, Considerations Affecting the Design of the Ideal Bomber Aircraft for the R.A.F. March - Aug '38, Note on Specification No. B.19/38, FO2 to DDOps(H), August 1938

117 2/2082, Table attached to 5A, RDA3 to DTD, 12.11.37

118 PRO: AIR 20/180, The Undefended Bomber, Policy, Table from OR1(A), 8.2.38

119 2/2958, 8A

120 ibid., 10B, Minutes of the Operational Requirements Committee, 11th August 1938

121 ibid., 10B, Minutes, paras. 15-17

Freeman (now Air Member for Development and Production) pointed out that the decision to design the aircraft around its turrets, "would lead to difficulties as the turrets had not yet been designed."[122] He said that designers would immediately ask for details of the turrets, and proposed that issue of the specification should be delayed until a turret design was available. This was not accepted - the turret problem was solved (!) by omitting the "Armament" section from the requirements and setting up a sub-committee to investigate the matter.[123]

9.3.4 The Demise of the Ideal Bomber

Following the Operational Requirements Committee meeting, the ACAS (Douglas) sent the amended Ideal Bomber Requirement (B.19/38)[124] to the Department of Development and Production for technical evaluation, with the comment,

> I am, of course, just as anxious as you are that this aeroplane should be the smallest and cheapest that can fulfil the role of a standard bomber for the future, and should be very glad if you would let me know what items in these requirements could reasonably be omitted or modified.[125]

It was soon evident that by enlarging upon the relatively modest recommendations of both their own Ideal Bomber paper and of the Bombing Committee, the Air Staff had gone beyond what was feasible in the then state of development of aviation technology.

The Director-General Research and Development (AVM A.W. Tedder) pointed out that the B.12/36 bomber, "taken all round comes somewhere near the optimum position accorded

122 ibid., 10B, Minutes, para. 7
123 ibid., 10B, Minutes, paras. 36 and 38
124 ibid., 10A,
125 ibid., ACAS to AMDP and DGRD, 13.8.38

to the various features of an ideal bomber" - and it was smaller than case C. But the proposed B.19/38 would be larger than case C, primarily because of the extra speed that was sought. It would have a span of 120 feet and a take-off weight of 80,000 lbs when overloaded.

Tedder explained that the Ideal Bomber analysis had considered a hypothetical family of aircraft which had been kept artificially comparable. In particular it had been assumed that suitable engines were available to match the different sizes of bomber which were considered. In reality there was no suitable engine to provide the performance now specified for B.19/38. In consequence bigger engines than were strictly needed would have to be used - giving more fuel, more weight, and hence a larger aircraft. But even so he was doubtful that the most powerful available engines (the Rolls Royce Vulture of 2,000 hp) would give the requested 300 mph cruising speed. He said that,

> The extra speed required is the dominant reason for the increase in size, cost, and reduction in numbers likely to be available for a given cost.

In Tedder's view not enough was known to draw up a specification for a successor to the B.12/36 designs - which had not yet flown. He was also very sceptical about the operation of such a large aircraft from all but a few RAF aerodromes.[126]

Following Tedder's comments on the technical feasibility of the Air Staff Requirement for an Ideal Bomber, the AMDP (Freeman) told the CAS that when the hypothetical investigation had been translated into the practical, "the very arguments which made us select the Ideal Bomber would make us throw out the 19/38." Freeman said that the Air Staff wanted a fast bomber which was armed with cannon and armoured, but in reality the more the defensive power was

[126] ibid., DGRD to AMDP, 7.9.38

increased the slower would be the bomber.[127] Both he and Tedder suggested that rather than proceeding with a specification for B.19/38 they should ask industry what could be done to improve on the B.12/36 bomber.

The ACAS (Douglas) and DCAS (Peirse) were opposed to this idea.[128,129] Peirse took the view that the Air Ministry should not pass on to industry a problem which it could not solve itself. He told the CAS (Newall) that, "the evils of going over the optimum size are probably greater than the drawbacks of not reaching it", and he stated what he saw as the essential requirements. These were, (a) improved speed, (b) improved defence, (c) armour protection, and (d) adequate range (which was now put at 2,500 miles). He continued that,

> Without the above, we shall not get the bombs to their destination. Therefore (a) to (d) must, to my mind, take precedence of (sic) bomb load. In fact, I would willingly give up 5000 lb. of bomb load to increase the chances of the remaining 7000 lb. reaching their objective, wherever that objective might be in Germany.

These views, which the CAS (Newall) agreed,[130] underline that the RAF's move towards large bombers in the 1930s was dominated by the operational demands - and their technical consequences - of bombing Germany, and not by a supposed change in bombing policy or predilection for large bombers. It is pertinent that the maximum bomb load of 7,000 lbs now deemed acceptable was less than that specified in 1936 for the medium bomber P.13/36, and half that of the heavy bomber B.12/36.

A curious episode then intervened in the Air Ministry's consideration of the Ideal Bomber. The question of the

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127 ibid., AMDP to CAS, 9.9.38
128 ibid., ACAS to CAS, 15.9.38
129 ibid., DCAS to CAS, 18.10.38
130 ibid., CAS to DCAS, 28.9.38

optimum size of bomber arose during Cabinet consideration of the expansion programme of the RAF in November 1938.

In his brief for the Cabinet meeting, the CAS advised the Secretary of State for Air that the Ideal Bomber paper, "represents the present Air Staff doctrine on this matter [of bomber size]". However, he then moved away from that paper's analysis of the most economic size of bomber, and put the emphasis on speed. He wrote that "High speed is the best form of defence against fighter attack", and that, "In the present stage of design technique and engine efficiency it is a fact that the fastest bomber is one of weight between 35,000 and 50,000 lbs." In regard to range, Newall said that, "Broadly speaking the larger the Bomber the greater the range."[131] There is much truth in that statement, but it was irrelevant to the Ideal Bomber study, for this had prescribed the same range for all the sizes of aircraft which were considered.

In fact by November 1938 the Air Staff's specification of an Ideal Bomber had gone far beyond the optimum weights quoted by Newall, mainly because they were seeking even higher speeds. This was of little consequence to the discussion in Cabinet, because it was concerned with the current RAF Expansion Scheme, and thus with expenditure on the bombers initiated in 1936 - and not on the Ideal Bomber.

In the Cabinet discussion[132] the Secretary of State for Air argued the case for large bombers as the best way of getting level with Germany, for large bombers gave more bomb lift for a given sum of money. The Foreign Secretary countered that if armament limitation should be discussed it would probably begin by banning very large bombers, and the Prime Minister was unhappy about concentrating on heavy bombers. He likened the position to that of the

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131 PRO: AIR 8/247, Brief for SoS for Ministerial Discussion C.P. 218 (38), Point 1

132 PRO: CAB 23/96, 19th Oct-21st Dec 1938, pages 150-172

development by Britain of the Dreadnought battleship, which although said to make other navies' battleships redundant, actually raised the cost of all battleships. He expressed the fear that concentration on Manchesters and Halifaxes might result in Germany building a "super-Halifax".

The irony of this debate was that the Manchester and Halifax were being built to an Air Staff requirement for a medium bomber, and moreover - contrary to Newall's brief - this called for them to be much faster than their heavier contemporary, the B.12/36.

The Cabinet told the Air Ministry to re-consider the policy of concentrating on very large bombers, and the Air Staff drew up a paper for Sir Horace Wilson, the Prime Minister's adviser. Not surprisingly, the preparation of this paper was seen as "a matter of considerable delicacy".[133] In fact the Air Staff avoided the speed *versus* weight dilemma posed by the 1936 bomber requirements by comparing a force of 1936 heavy bombers (B.12/36 Stirlings) with one of Wellingtons - a medium bomber of 1932 vintage. They argued that,

> Large bombers, since they are faster, better defended, able to operate singly and make full use of cloud flying and avoiding action, are less vulnerable to fighter attack. <u>It seems certain that the fitting of 'cannon' gun turrets will be essential in future types of bombers and this is not practicable in the smaller class</u>."[134]

The paper stressed the danger of regarding bomb lift as the only criterion when determining the size of the bomber force.[135] It expressed the fear that if an enemy with small bombers had established the infrastructure for a large number of aircraft, and then changed to large

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133 PRO: AIR 8/257, <u>The Ideal Bomber</u>, PS to 2nd PUS to PS to CAS, 15.12.38

134 9/82, 22A, Air Staff Note on Size of Bomber Aircraft, F.H. Sandford to Sir Horace Wilson, 23rd December 1938, Summary of Conclusions, para. 29(a)

135 ibid., 22A, para. 32

bombers, it would take many years for the RAF to respond. The Air Staff deduced that the United Kingdom's infrastructure must be ready to support as great a force as that of enemy.[136]

Clearly great delicacy had been employed in coming to these 'having it both ways' conclusions, which made a nonsense of Newall's statement that the Ideal Bomber paper gave Air Staff doctrine on the size of bomber aircraft. Not only was that paper based fundamentally upon the concept of bomb lift, but part of the case for a small number of large bombers was the reduction in infrastructure which would follow.

It has been seen above that the DGRD (Tedder) and AMDP (Freeman) had both criticised the Air Staff for seeking too high a speed for the Ideal Bomber. But following the Cabinet discussion Tedder put to the CAS, with Freeman's acquiescence, his thoughts as to why the RAF was forced to large bombers. He first reiterated the point that the longer a bomber is over enemy territory the longer will it be exposed to attack, and that "Therefore the prime requirement of the bomber is speed".

Tedder then explained that speed depended upon drag and engine power, and as little improvement in drag seemed likely, increased performance needed more power. He wrote,

> Any increase in horsepower by fitting bigger engines, increases the weight of the power units, the fuel required for a given range and the weight of the tanks, and also increases the structure weight of the aircraft.
> Consequently, even if speed alone were the demand, the faster aircraft would inevitably be bigger.

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136 ibid., 22A, para. 26

He added that factors such as more range, more navigation equipment, and more armour to counter heavier fighter armament, all pointed the same way.[137]

Nevertheless, the Air Staff responded to Tedder's earlier criticism of the Ideal Bomber and drew up new requirements with the cruising speed reduced to 280 mph and the maximum bomb load reduced to 9,000 lbs. The landing weight, with no bombs and a reduced fuel load, was to be limited to 50,000 lbs. But these concessions were offset by an increase in the operational range with maximum load from 2,000 miles to 2,500 miles, and retention of a maximum take-off of 900 yards and a reinforcing range of 3,500 miles at operational cruising power - all more onerous that in the Ideal Bomber studies.[138]

In sending these to Freeman, Douglas drew attention to a comment from the Secretary of State for Air that the Ministry was often criticised for delays in production, and that the apparent gestation period of a new design was often artificially lengthened by the specification bearing a date considerably earlier than when contracts were issued to firms. As contracts for B.19/38 could not now go out before the 1939 financial year, the SoS requested that it should have a 1939 number.[139] The designation B.19/38 was changed to B.1/39.

The new requirements were sent to aircraft firms in January 1939,[140] and nine tenders were received. These convinced the AMDP's Department that in the current state of knowledge of aerodynamics and of turret design even the reduced specification could not be met.[141] Freeman proposed that discussions with the two firms (Bristol and Handley Page) who had made the most promising proposals

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137 8/257, DGRD (through AMDP) to CAS, 22.11.38

138 2/2958, 28A, Appendix "B" to Air Staff Requirements for a Bomber Landplane No. B.1/39

139 ibid., ACAS to AMDP, 13.12.38

140 ibid., DTD to ADC(A), 5.1.39

141 ibid., DGRD to AMDP, 13.7.39

should be continued to see what compromises were possible, and with a view to ordering development prototypes.[142]

This minute produced an interesting reaction from Saundby (now Director of Operational Requirements). He told the CAS that although the Bombing Committee had recommended that the Air Staff should prepare draft requirements for the Ideal Bomber, his branch had not intended to issue them until there was some experience of the Stirling, Halifax and Manchester. However, they had been strongly urged by the AMDP to complete and issue requirements, as work was needed to occupy designs staffs in industry. Saundby claimed that the Stirling, Halifax and Manchester would meet their requirements for some time as regards range, bomb load, and, probably, speed. Their weak point was reliance on machine guns for defence. This would be remedied in the Mark II of each type, with upper and lower amidships turrets carrying 20 mm guns. Saundby said that, "I agree with A.M.D.P. that, if these Mark II designs are successful, they will meet our requirements until the B.1/39, developed in a systematic way, comes along."[143]

It has been noted above that when Freeman realised that the Air Staff were calling for turrets which did not exist, he had proposed delaying the project - despite his concern with the need for work for design staffs. It was the Air Staff who undermined the Ideal Bomber project by specifying a performance beyond the limits of the feasible. Whilst recognising the importance of speed, the Air Staff tried to keep all other desirable characteristics of a bomber as well. As Freeman had graphically put it to the CAS (Newall), "We are, or so it seems to me, trying to produce the air equivalent of destroyers with heavy armour and 15" guns: the result is not likely to be satisfactory."[144]

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[142] ibid., AMDP to CAS, 13.7.39
[143] ibid., DOR to CAS, 19.7.39
[144] ibid., AMDP to CAS, 9.9.38

The advocates of a speed bomber also sought the best of both worlds, and failed, as is shown in the next section. Furthermore, the Air Staff's expectation that the bombers then under development could be retrospectively fitted with 20mm cannon turrets was doomed to failure, as has been discussed in chapter 8.3.4.

9.4 SPEED BOMBERS

The concept of a bomber which would rely entirely upon its speed to avoid hostile fighters interested some senior officers in the RAF for many years. In chapter 4.2.2.1 it noted that in 1928 Chamier suggested that such an aircraft might be the only feasible form of attack in daylight. In the 1930s advances in aviation appeared to make the idea of a fast unarmed bomber a realistic proposition.

The McRobertson Mildenhall to Melbourne Race of 1934 was won by the purpose-built de Havilland DH 88 Comet.[145] The Comet was a long-range twin-engined monoplane which was considerably faster than the fastest fighter then in RAF service. But the Air Staff did not see this as presaging the introduction of fast unarmed bombers. They believed that the success of the Comet was due to a fortuitous coming together of a number of recent design developments, and that a fighter produced under the same conditions as the Comet would have been over 40 mph faster. They deduced that the lesson to be learnt was that they must have sufficient staff to watch design trends so that the RAF could not be overtaken.[146] Nevertheless, there were other factors which kept the idea of a speed bomber alive.

In 1935 Air Ministry Intelligence received reports that a Heinkel civil aircraft had been converted to a fast

[145] Ogilvy, D., DH 88 (Comet), 1984
[146] 6/43, EPM 19(35)), The Possibility of Dispensing with the Armament in the Light Bomber Class, Air Staff Note, 22nd June 1935

unarmed bomber (probably the future He 111).[147] The Ministry may also have known that in 1936 Junkers were investigating the design of a very fast but unarmed bomber - which became the Ju 88.[148]

Also in 1935, the Royal Aircraft Establishment investigated the possibility of a high-speed day bomber with two Merlin engines and armed with three machine guns in streamlined mountings. It suggested that with a speed of 330 mph it would be difficult to attack by fighters.[149] This proposal was included as development type in the draft 1936 Experimental Aircraft Programme, as was a "High Performance Aeroplane" which could be produced in war by firms used to working in wood.[150] These ideas were not then taken up - there was great pressure to reduce the number of new types under development.[151] A following RAE paper[152] on a high-speed bomber to meet the B.1/35 requirements was circulated to the aircraft industry,[153] and may have led to a number of proposals for fast bombers, some armed, some not, which emanated from industry in the late 1930s.[154]

Whilst none of these were seen as a sufficient advance on the performance then expected of the Avro P.13/36 design,[155] they led Oxland (with the DCAS's approval[156]) to clarify Air Staff policy on the interplay between speed and armament. He wrote that,

> Our own views as to the relative importance of speed and armament may be summarised by saying that we think 80% of the defence of the bomber lies in its speed and the remaining 20% lies in its armament. But that 20% is essential for a day bomber.

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147 ibid., EPM 9/35, German Policy on Supercharging and Armed Bombers
148 Griehl, M., Junkers Ju 88, Star of the Luftwaffe, 1990, page 8
149 2/2082, 6A, Chief Superintendent RAE to DTD, 4th April 1935
150 2/1402, 8A, Air Staff Types Required
151 ibid., AMRD to DCAS, 18.10.35
152 2/2082, 8A, 1.5.35
153 ibid., 11A, 28.5.35
154 20/180, proposals from Handley Page, Short Bros., Gloster and Napier are mentioned.
155 ibid., OR1 to DDOR, 22.2.38, and Table from OR1(a)
156 ibid., DDOR to DCAS, 30.3.37

He accepted that, "for night work, when all defensive armament is comparatively useless to the bomber, we may be justified in sacrificing armament for speed." But he saw that to develop such a type would mean reverting to the policy of specialist day and night bombers.[157] Freeman agreed with these views.[158]

The most prominent input to consideration of a speed bomber came from Bomber Command. As discussed in chapter 8.2, the senior staff of the ADGB (and of Bomber Command from July of that year) pressed for higher speed in the 1936 bomber requirements, particularly for P.13/36. They expressed a willingness to forego some or all defensive armament to obtain higher speeds. Ludlow-Hewitt, appointed AOC-in-C of Bomber Command in September 1937, took up this concept when the Operational Requirements Committee met to discuss the B.17/37 medium bomber project. He asked for consideration of a higher speed, if need be at the expense of reducing range,[159] and saw a place for a very high-speed unarmed bomber.[160]

Liptrot's comment on the proposal to reduce the range of B.17/37 underlines the point which has been emphasised in this thesis that speed was the prime driving force which led the RAF to larger bombers. He said that a reduction in range would have little effect on speed, and that, "The factor most responsible for the low speed was the desire of the Air Staff to keep the aeroplane as small as possible."[161]

The Ideal Bomber paper recommended that an unarmed high-speed bomber should not be developed.[162] But before the paper was discussed by the Bombing Committee in May 1938,

157 ibid., Oxland to AMRD, March 1937
158 ibid., Freeman to DDOR, 23.3.37
159 9/77, Minutes of Operational Requirements Committee, 24th November 1937, para. 20
160 ibid., para. 57
161 ibid., para. 22
162 9/82, 19A, para. 23

Ludlow-Hewitt put in a further plea for a bomber which would depend primarily on speed to evade enemy fighters. He argued that in war, in addition to heavy destructive attacks, there would be a need for frequent harassing attacks. For these a fast light bomber would be required, and he sent Freeman (then AMRD) his specification for a such an aircraft. It was not for an unarmed bomber, which Ludlow-Hewitt said was a misnomer, but for a "speed bomber" - one which, "must depend mainly upon its speed to evade enemy defence."[163]

Ludlow-Hewitt's definition was not incompatible with Oxland's statement of Air Staff policy as quoted above, but their response to his specification was that a speed bomber was operationally inefficient as a bomb carrier, would need 20mm guns, and could quickly become obsolete as fighter speeds increased. Policy would be to make harassing attacks with single heavily-armed standard bombers.[164] The Ideal Bomber paper claimed that in this way a number of targets could be attacked by one aircraft in one sortie (quoted in chapter 2.2.2).

Following Bombing Committee's discussion of the Ideal Bomber, Ludlow-Hewitt put his advocacy of a fast bomber on a formal basis by writing directly to the Under Secretary of State, Air Ministry, and repeated the specification which he had sent to Freeman. This did not specify a speed, and included some armour and considerable armament - two fixed forward guns, and two pairs of rear guns in flush mountings. The bomb load was to be 1,000 lbs and the range 1,500 miles. He added that such an aircraft would also be useful for photographic reconnaissance.[165]

On learning that the CAS was not persuaded to order a speed bomber, Ludlow-Hewitt repeated his fear that Bomber

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163 PRO: AIR 14/251, Bomber Command Requirements in New Type Aircraft - High Speed Bomber, 2A, AOC-in-C to AMDP, 23 April 1938

164 20/84, The Speed Bomber, undated, c.May/June 1938

165 14/251, Ludlow-Hewitt to USoS, 19th July 1938

Command's conventional bombers were inadequately armed, and advanced another use for his speed bomber. He said that Germany, Italy and Japan were escorting their bombers with fighters, (presumably in Spain and China), but that should the RAF find this to be necessary they had no escort fighter. He suggested that a large high-speed aircraft might also serve that need.[166]

Undeterred by the constant refusal to develop a speed bomber, Ludlow-Hewitt again raised the matter at an official level in August 1939. He then wrote to say that the speed bomber need not be thought of as a light bomber. He suggested that there was a need for an aircraft of some 30,000 lbs, with a speed 40-70 mph faster than the Stirling or the B.1/39 (Ideal Bomber).

In view of the history of the interest in a fast bomber outlined above, and the Air Staff's clear policy of daylight bombing which runs throughout this thesis, Postan's description of the origin of the de Havilland Mosquito is astounding. He said that the firm, "had to think out for themselves the whole tactical and strategic purpose of the aircraft", and that,

> While the Air Ministry were *still wholly devoted to the doctrine of night bombing* by heavy bombers, Sir Geoffrey de Havilland conceived the idea of day bombing by fast unarmed aircraft.

and that, "In the circumstances of 1939-40 this was an *entirely new and independent* set of ideas".[167]

The facts are that on 20th September 1939 Captain Geoffrey de Havilland referred to a recent conversation with Freeman, and wrote that he believed that his firm could produce a bomber of such outstanding performance that little defensive equipment would be needed.[168] (Goulding

166 ibid., 6A, Ludlow-Hewitt to CAS, 3rd December 1938

167 Postan, page 85, italics added

168 PRO: AVIA 15/4, High Speed Bomber Proposed by de Havillands Mosquito B1/40, 1A, Geoffrey de Havilland to Freeman, 20th September 1939

and Moyes make the point that Freeman would have known of the RAE fast bomber study and that he was close to de Havilland.[169])

The DGRD (Tedder) told de Havilland that the Ministry had been considering such a form of aircraft, and had asked other firms to do layouts. He said that they sought a bomb load of 2,000 lbs and a range of 2,000 miles, and that,

> The desirability of entire absence of defensive armament is not generally accepted. Its acceptance would depend very much on the additional speed that it would permit, as demonstrated in tests on the prototype.[170]

Following a meeting between the Ministry's technical staff and de Havilland,[171] the company looked at the design of an aircraft with two Griffon engines and a four-gun rear turret.[172] On 20th November 1939 Tedder told the firm that the Ministry were intending to order two prototypes to that design.[173]

This plan was made redundant at a meeting held two days later. Freeman then told the de Havilland that if it would guarantee to produce a twin Merlin unarmed aircraft in nine months, followed by a Griffon engined version nine months later, and then a Sabre engined version, he would recommend such a programme to the Air Council as a gamble.[174] The Air Ministry then immediately discussed with the company an operational requirement to support the development of a high-speed light reconnaissance aircraft on these lines. It was to be capable of easy conversion to a fighter, or to a bomber with a bomb load of 1,000 lbs

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169 Goulding and Moyes, page 92

170 AVIA 15/4, 5A, Tedder to de Havilland, 3rd October 1939

171 ibid., 9A, meeting arranged for 14.10.39

172 ibid., de Havillands to Grinsted, 8th November 1939

173 ibid., 25A, Tedder to de Havilland, 20th November 1939

174 ibid., 37A, Minutes of a meeting on 22nd November 1939 to discuss a new de Havilland Bomber aircraft

and fuel for 2,000 miles from a 900 yd take-off.[175] This project was to become the Mosquito.

It was after the events described above that the Air Ministry called a meeting to consider the proposals for a high-speed bomber put forward by Ludlow-Hewitt.[176] It was explained that all analyses of such ideas from Bomber Command had concluded that they were a bad compromise - in trying to get high speed and modern armament neither could be attained. The crux of the matter, as put by the AMDP (Freeman), was the balance between speed and armament. He asked if the Command would be prepared to dispense with armament if a bomber could be produced which was faster than fighters.

This was not acceptable to Ludlow-Hewitt, although he thought that it might be useful for reconnaissance. He seemed to miss Freeman's point entirely with the comment that, as the object was to make harassing attacks on places previously heavily attacked, the bomber could expect to be intercepted, and would therefore need some defence before it reached cloud cover. Needless to say, Freeman was disappointed with this reply, for he had hoped that it would be agreed that if a bomber was faster than opposing fighters the question of interception would not arise.

The contribution of the ACAS (Douglas) to the discussion epitomised the RAF's belief in the viability of daylight operation of heavily-armed bombers. He suggested that to rely too much on speed was to make the same mistake as the Germans, whereas the Stirling and Manchester, "could very well be used singly or in small formations to follow up the main attack".[177]

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175 ibid., 37B

176 14/251, 12B, High Speed Bomber; Minutes of Conference on 12th December 1939

177 ibid., 12B, para.6

Despite these unhelpful contributions, Freeman obtained agreement to pursue two lines of development - the first of which he had already promised to de Havilland. Scheme I was for an unarmed bomber with a bomb load of 1,000 lbs and range of 1,500 miles. Scheme II was a longer-term project for a large high-speed bomber based upon the Manchester.

For Scheme I it was recognised that a new model would be needed each year to take advantage of engine development so as to maintain a speed advantage over contemporary fighters - as Freeman had demanded of de Havilland. A good view rearward was also deemed essential, because an unarmed bomber would cruise below its maximum speed and its crew would need to see an attacking fighter in time to accelerate away.[178]

The Deputy Director-General Production advised that if the new aircraft was to be produced quickly, it would disrupt current aircraft production arrangements unless it was of wooden construction. He said that this emphasised the advantage of using a firm like de Havilland.[179] Their proposal was before the meeting and it was decided to proceed with it.[180]

9.5 SUMMARY

This chapter has described the RAF's views on the desirable characteristics of its home defence aircraft in the years immediately preceding the outbreak of war. It has been shown that as developments in aeronautics gave the potential for improved flight performance, aerodrome size became a dominant factor in the setting of operational requirements. Otherwise, no new thoughts emerged for either fighters or bombers.

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178 ibid., 15A, Bomber Command to Air Ministry, January 1940
179 ibid., 12B, para. 21
180 ibid., 12B, para. 23

The Air Staff continued to pursue the idea that a high-performance turret fighter was needed to successfully attack formations of bombers - more so if the bombers were armoured against attack from astern. The Ideal Bomber investigation was based upon the long-held belief that bombers could defend themselves in daylight when on deep penetration attacks into hostile airspace, and emphasised that the speed required to reduce exposure to fighter attack inevitably led to large bombers. In the next and final chapter it will be seen that both lines of development were soon found to be unsoundly based when tested in war. It was the much derided - but never quite forgotten - unarmed fast bomber which was the most successful outcome of the immediate pre-war (or correctly pre-phoney war) period.

10. CONCLUSIONS

This final chapter first reviews an issue which has run throughout this thesis - the inaccuracy of much of the literature on Air Ministry policy and actions relating to aircraft development. It then compares the experience of operations in the first year of the Second World War with the doctrine of air warfare which was adopted by the RAF between the wars. It was this doctrine which underlay the operational requirements which emerged from the management and consultation processes outlined in chapter 3. These are reviewed in section 10.3. The bomber and fighter requirements which were set in the 1930s are then assessed in relation to the operational situations which were encountered in war - which in most instances were very different from those expected.

Finally, some thoughts are given on how Air Staff requirements might have developed had it not believed in the power of self-defending day bomber formations. It is suggested that there would have been little change.

10.1 MYTHS AND LEGENDS REFUTED

This thesis is concerned with the aircraft performance characteristics which the RAF saw as required to enable it to carry out its home defence role. In the course of the research it has been found that published views on these, and on the origin of the aircraft with which the RAF entered and fought the war, are in many instances unsound, particularly in their citing of the intentions of the Air Ministry. Correct accounts, taken from the Air Ministry files of the period, have been given as they have arisen in earlier chapters. No further comment is required, except to suggest that writers on air policy should be wary of supporting their opinions by reference to secondary sources which purport to give details of aircraft specifications, and the policy behind them, but which in fact do not - the "legendary" role of Sorley is a salutary example.

Common charges against the Air Ministry are that it was out-of-date in its requirements for aircraft and their armament as compared with other countries; that it was primarily concerned with aircraft for Air Control, suspicious of monoplanes, slow to respond to technical development, and sought big (night) bombers to implement a new bombing policy. The reader is led to believe that military aircraft produced in other countries were more advanced than those sought by the Air Staff, and that the British aircraft which proved successful were mostly the product of initiatives (and funding) from industry. It has been shown that these claims are largely without foundation.

Of course the Air Ministry did not design aircraft. The success in translating operational requirements into outstanding machines was the achievement of British aircraft designers - but as noted at the beginning of this thesis, and confirmed throughout, they were guided and funded by the Air Ministry. Even the so-called "purest case"[1] of private venture designs - the Mosquito - has been shown to stem from a long line of thinking by RAF officers, regarding both a speed bomber and an aircraft made of wood.

Many critical opinions stem from a failure to notice factors which were highly relevant to RAF thinking at the time. These include the importance of the day and night operational capability demanded of the RAF's standard fighter, and of all fighters after 1935; the belief that bomber formations could not be broken up by single-seat fighters, and the consequent effort put into attempts to

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[1] Postan, page 84

develop a satisfactory multi-seat turret fighter; and the crucial decisions made in 1934-35 to drastically reduce the fuel load of fighters, which had a major influence on the practicality of the eight-gun fighters.

Little notice is taken of the profound impact on bomber development of disarmament discussions in the early 1930s - which as has been shown were still of some concern in 1936 and 1938. The RAF's assessment of the operational requirements for bombing Germany in daylight, and their technical consequences, are misunderstood, and interpreted in retrospect as a change in bombing policy. It is little appreciated that the operational requirements for war with Germany were seen to demand not only long range, but also high speed to reduce exposure to fighter attack in daylight. This requirement was a major factor in the evolution of big bombers, despite the desire to keep them as small as possible.

The crucial importance of assisted take-off in meeting the 1936 bomber requirements for long range and large bomb loads is unnoticed or brushed aside, and its replacement by airfield development is ignored. Yet it was this which enabled the catapult take-off performance called for in 1936 to be exploited in war.

The current research has shown that much of the criticism in the literature of the Air Ministry is unjustified. In terms of the aircraft it sought the Air Ministry was thoughtful and forward looking. When put to the test of war, the fighting performance which the Ministry demanded for its home defence fighters and bombers was at least as good as those sought or achieved elsewhere, and in some respects superior.

That this was so with respect to Germany is evident from combat experience in the first year of the war. Fighter Command did win the Battle of Britain, although outnumbered by contemporary German fighters. German bombers were no more successful in defending themselves in daylight than were RAF bombers. When both were forced to bombing by night, and heavy bomb loads were needed, those written into Air Staff Requirements in 1936 were far greater than any achieved by German aircraft at any time during the war.

As regards comparison with America, when consideration was given to the purchase of American aircraft in the desperate days of May 1940, the Cabinet was told that, "the aircraft types now in service with the United States Army were obsolete, and unsuitable for European conditions."[2] Earlier in 1940, it was found that,

> At the present time no long range American bombers have an armament which in our view is in any way adequate. In particular none has power-operated turrets, which we consider to be indispensable.[3]

The first American fighter units which operated from Britain were equipped with Spitfires,[4] and when these were replaced by an early model of the P-47 (Thunderbolt), it could "barely hold its own against the Luftwaffe".[5]

The French military aircraft which were in service in 1939-40 were generally out-classed by those of Germany.[6,7] In terms of performance and armament, only the few available Dewoitine D.520 fighters were comparable with the Me 109 or with the Hurricane and Spitfire. Some French bombers were armed with a 20mm cannon, but their performance suffered from the policy of seeking a multi-purpose *bombardement-combat-reconnaissance* type.[8]

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[2] PRO: CAB 65/7, War Cabinet 124(40) 16th May 1940, page 149, section 12

[3] PRO: AIR 8/293, Aircraft Potential in U.S.A. Pleven and Greenly Investigation, ACAS to PUS, 15.1.40

[4] Macfarland, page 82

[5] ibid., page 89

[6] Griffin, D.E., "The Battle of France 1940", Aerospace Historian, Vol 21 (1974), No.3

[7] Kirkland, F.R., "French Air Strength in May 1940", Air Power History, Vol 40 (1993), No.1

[8] Vennesson, P., "Institution and Air power: The Making of the French Air Force", JSS, Vol 18 (1995), No.1

10.2 DOCTRINE *versus* REALITY

With regard to the strategic assessment which the RAF had put forward in the inter-war years the story is simply told. The German Air Force did not attempt an immediate knock-out blow, nor did the RAF embark upon an immediate counter-offensive against German military installations and industry. When air attacks on London were made, they were on a scale far greater than the 100 tons per day for a few days which had been thought to be sufficient to produce devastation. In September, October and November 1940 a daily average of over 200 tons was dropped on London, and a lower level of attack continued through to the spring of 1941.[9] But when faced with a resolute, well-organised and radar-aided defence, bombing accuracy was much less than had been predicted. Bombing caused neither the level of destruction and casualties that had been calculated nor the collapse of civilian morale. The words of Field Marshal Sir Henry Wilson in 1921 proved correct. His comment on claims that a future war would be decided by devastating air attacks was that it was not,

> profitable to pursue the abstract discussion of such conjectural phenomena, for it must be very many years before the aerial power of our potential enemies can attain the gigantic proportions suggested, by which time it may be that science will have designed a correspondingly effective antidote, while it is to be hoped that this country may then be peopled by a less war weary and more robust generation.[10]

It was in the absence of any known antidote to bombing that the RAF had adopted a doctrine of air warfare which depended upon the supremacy of the bomber, and throughout the inter-war period it held to that assessment. Changes in the international situation did not alter its belief that the only effective way of mitigating air attacks on London was to threaten and, if needs be, to implement, a

[9] Wood and Dempster, Appendix 23, and Overy, page 36

[10] PRO: AIR 8/6, The Air Force in relation to the Army and Navy, note by CIGS, 26.9.21

counter offensive. Nor did it believe that advances in science and engineering undermined the validity of the means by which that doctrine was to be given effect - accurate daylight bombing by self-defending bombers.

This theory, shared at the time by other air forces, was soon disproved. Webster and Frankland comment that,

> More was learnt about the potentialities and limitations of the day bomber formation in a few months of war experience than had been gained from the previous twenty years of theorising on the basis of fragmentary and often obsolete evidence derived from the First World War, the Sino-Japanese War and the Spanish Civil War.[11]

The failure of day bombing theory had its counterpart in the unanticipated success of RAF fighters against daylight raids on Britain, even when German bombers were escorted. Faced with these facts, both British and German air forces turned to bombing by night, and this exposed other deficiencies in pre-war assessments.

10.3 THE MANAGEMENT OF OPERATIONAL REQUIREMENTS

The introduction in 1933-34 of a formal procedure for the initiation of new aircraft types has been described in chapter 3.3.2. The system then established concentrated power into the hands of the Air Staff. But the establishment of a branch whose sole responsibility was for operational requirements did not lead to a careful appraisal of the aircraft characteristics which were needed to implement RAF home defence strategy. There were no studies of the kind carried out in earlier years by T.C.R. Higgins, Welsh and Chamier. The review of operational duties undertaken - with some reluctance - in 1935, went little further than to consider the allocation of different types of aircraft to home and overseas

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[11] Webster and Frankland, Vol I, page 190

stations, and the prospects for reducing the number of classes of aircraft. Even the Air Staff's Ideal Bomber appreciation was based primarily upon the economics of a bomber force - its novel contribution to operational analysis was to assume that the combined defensive power of a formation of bombers was no longer needed, for which no evidence was cited.

The Operational Requirements branch became increasingly involved in detail, and, as has been shown, did not think through some important operational aspects of the aircraft it prescribed. Omissions which have been discussed are the interaction between fighter and bomber armament, the problems of night fighting and bombing, and the wider implications of assisted take-off schemes. It also pursued the amalgamation of the medium and torpedo bomber classes without examining the practicality of torpedo dropping, although in this instance with fortuitous beneficial consequences.

Perhaps the most notable of these omissions was the Air Staff's failure to relate their own forward-looking approach to fighter armament to its implications for the defence of bombers. Yet this was an issue of great relevance to the RAF's own doctrine of air warfare - the power of bombers to defend themselves.

From 1927 to 1932 there were operational requirements (and experiments) which increased fixed-gun fighter armament from the two machine guns of 1918 to four (F.20/27 and F.7/30) or six (F.10/27 and F.16/33). Even so, the armament specified for bombers in those years was no more than three single-gun stations for B.19/27 and B.9/32. This level of bomber defence was continued in 1934 and 1935 (B.3/34 and B.1/35), even though contemporary requirements for fighters by then called for eight guns - and it was expected that other nations would follow this trend.

Although the final form of B.1/35 called for a two-gun tail turret, and the 1936 bomber requirements both included a four machine-gun tail turret, by that time the Air Staff had launched the cannon fighter (F.37/35) - with four 20mm cannon - and in 1937 saw the alternative as a twelve machine-gun fighter (F.18/37).

Despite this failure over many years to bring bomber armament into line with that of contemporary fixed-gun fighters, the Air Staff's confidence in the defensive power of bombers against such fighters led to their near obsession with fighters with moveable guns. In the early 1930s development of a high performance single-seater was postponed in favour of such developments, and up to 1939 great hopes were placed upon such types. This obsession had its impact on bomber requirements through the insistence on the need for under turrets for defence against (non-existent) hostile turret fighters.

The lack of interaction between the operational requirements for fighters and bombers perhaps followed from a weakness in Ludlow-Hewitt's scheme for an Operational Requirements Committee. This made provision for a representative only of the "appropriate Command at home, if applicable". Thus the opportunity for an exchange of views between fighter and bomber officers was not taken.

On some other issues the inclusion of the operational Commands in discussions of operational requirements was clearly beneficial. Examples are the Commands' views on the endurance of fighters, and their pressure for higher speeds for bombers. Perhaps the most surprising omission was the failure of ADGB/Bomber Command officers to question seriously the practicality of launching the bomber striking force by catapult.

That the Air Staff did not follow through some implications of their operational requirements may be traced to the fact that responsibility for them was first taken on by the Flying Operations 1 section of the Air Staff. This section had initially been established specifically to consider the strategy and tactics of home defence, but Portal led it into concentration on operational requirements. When in 1934, as discussed in chapter 3.2.2, it was recognised that this had become its major role, Williams and Sorley were transferred to the new Operational Requirements section. The study of home defence strategy was separated, and diminished to the extent that it was given to the officer who was also responsible for RAF policy with respect to civil unrest.[12] Thus any link which there had been between operational requirements and home defence operational considerations was further weakened.

Another criticism of the Air Ministry's management of operational requirements is the lack of continuity of thought on a number of major issues. This seems to have been a consequence of the relatively short-term appointment of RAF officers to the Air Staff. How else can one account for the all too frequent resurrection of previously rejected ideas, the inversion of arguments, and contradictory decisions? Examples are the gyrations of policy in regard to multi-seat fighters, discussed in chapters 4, 6 and 9, and those on airfield policy, described in chapter 9.

The Air Ministry was not unaware that lack of continuity posed a problem. On such a vital matter as air defence intelligence communications - the core of Fighter Command's operational control - the Ministry decided that the chairmanship of the Technical Committee should go to the Assistant Engineer-in-Chief of the Post Office - "as

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[12] 2/673, page 15

R.A.F. personnel are liable to change rapidly".[13] They were also aware of the consequences of a rapid turnover of policy staff in other Service departments, exemplified by a note from Dowding to Buchanan following discussions with the Admiralty. He wrote that, "when you have taken action I should like this file to go back to D.C.A.S to confirm this policy officially with the Admiralty. Otherwise I fear that the next incumbent of DNAD's[14] post will have his own ideas & want to scrap all previous policy."[15] That in some instances this is exactly what happened within the Air Ministry apparently went largely unnoticed and uncorrected.

Continuity was less of a problem in the technical branches of the Air Ministry, no doubt because there was a large component of permanent civilian staff. Respected figures such as Buchanan and Liptrot were in post throughout the 1930s - Liptrot from the early 1920s. Perhaps even more important in ensuring continuity of approach was that Dowding was the AMSR, then AMRD, through the vital years September 1930 to May 1936.

10.4 OPERATIONAL REQUIREMENTS IN ACTION

The aircraft which were operated by the RAF in the first eighteen months of war were those derived from operational requirements which had been set many years before. These had been chosen to implement the pattern of air warfare expected by the RAF. Later in the war the strategic situation, and the pattern of air warfare, had changed completely from that envisaged before the war. British aircraft development responded to these circumstances largely through the modification and improvement of the

[13] PRO: AIR 2/1672, Air Defence Intelligence Reporting System Formation of Co-ordination Committee, FO1 to DCAS, 7.12.35

[14] Director of Naval Air Division

[15] PRO: AIR 2/607, Design Branch Specification No. O.27/34 Fighter Dive Bomber, Dowding to [Buchanan], 15.12.34

aircraft types which had been defined before the war[16] - mostly before 1937 - and based upon concepts established in the 1920s.

Throughout the inter-war years the operational characteristics which the RAF sought to implement its doctrine changed little in principle, although greatly in quantity. The development of increasingly powerful engines was used to get higher speeds from heavier aircraft which then had the potential to carry greater military loads. For both bombers and fighters this potential could be exploited fully only by building larger airfields.

Obviously an important input was the emergence of Germany as the most likely enemy able to strike Britain through air power. To attack Berlin the counter-offensive bomber force would need a much greater operational range than had hitherto been sought when Paris was the prime target, and this was seen to need both high speed and powerful defensive armament.. Speed and armament are not good bedfellows in bomber design, and much effort was spent on searching for an acceptable compromise. But belief in the viability of self-defending bombers did not waver, nor did its counterpart - doubts about the ability of RAF single-seat fighters to defend London. War was to demonstrate that both these beliefs were unfounded.

10.4.1 Bombers

By the end of 1939 the RAF's belief that daylight bombing by self-defending formations was sustainable was undermined, even though no penetration of Germany had been attempted. In the words of Air Marshal Sir Phillip Joubert, Bomber Command operations against the German

[16] Postan, page 159

fleet, "had cost us dear".[17] Armed reconnaissance missions by formations of Hampdens and Wellingtons derived from specification B.9/32 suffered severe losses. The operations themselves are well-trodden ground. They, and the consequent move to night bombing, are fully described in Webster and Frankland.[18]

It was believed that the B.9/32 bombers' lack of beam defence was their weakness against fighter attack. Thus in May 1940, when the Air Fighting Committee met to consider "The defensive armament of heavy bombers", and to decide policy which the ACAS (Douglas) said might last until the end of the war,[19] it was decided to fit mid-upper turrets to the bombers of the 1936 programme. This was in spite of Dowding's re-assertion of the pre-war view that at modern bomber speeds (over 200 mph) beam attacks would not be feasible. But he noted that some of the bombers had been flying at what he called 1914-18 war speeds - "140 m.p.h., (e.g. the Wellington)" - and that then beam attacks were feasible.[20] This was a further instance of the difference between operational practice and performance as seen within the Air Ministry, for in September 1939 the operational cruising speed of the Wellington had been put at 212 mph.[21]

Despite the inability of the bombers derived from B.9/32 to defend themselves, the Air Staff hoped that the faster, better armed and armoured bombers from the 1936 programme could operate in daylight. Webster and Frankland note that,

> The belief still lingered that heavy bombers might yet be cast into self-defending formations capable of

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[17] PRO: AIR 20/225, Operations against the German Fleet Dec 1939 - Feb.'40, Joubert to DCAS, 29.12.39

[18] Webster and Frankland, Vol I, Chapter IV

[19] 5/1126, Minutes of 21st meeting of the Air Fighting Committee, 5th April 1940, para.1

[20] ibid., para.7

[21] PRO: AIR 20/235, Part II Attacks on German Fleet 6th Sept '39 - 26th May '43, A. Durston [DNO] to DDOps, 8.9.39, para. 5

> carrying the war to the interior of Germany in daylight.[22]

This belief was supported by tactical trials of the P.13/36 bombers, which concluded that they could be operated in daylight if there was some cloud cover. Indeed it was expected that the Halifax would be particularly able to defend itself - even flying alone - when fitted with a mid-upper turret.[23,24]

Soon after each type derived from the 1936 specifications came into service it was sent upon daylight raids, although not to the interior of Germany. In July 1941 small formations of Stirlings and Halifaxes attacked the French Atlantic ports. But after an attack by fourteen Halifaxes on La Pallice had suffered heavy casualties,[25] Bomber Command concluded that, "unsupported daylight attacks by heavies when faced with equal or slightly superior numbers of fighters are not a practical proposition".[26] Nevertheless, some further daylight attacks were mounted, notably with Lancasters (which can be directly traced back to P.13/36). Losses were high and the results were disappointing.[27]

The RAF was forced to night attacks as the means of conducting a bombing offensive against Germany throughout most of the war. It lost not only the supposed precision of day bombing, but also the prospect of a continuous day and night offensive.

Bombing by day had been envisaged as the main operational role in all but one of the bomber operational requirements specified in the 1930s. Nevertheless, there was always in

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[22] Webster and Frankland, page 239

[23] PRO: AIR 2/1651, Air Fighting Cttee (papers), 193A, Tactical Trials of Halifax Aircraft, 3.6.41

[24] ibid., 173A, Tactical Trials - Manchester Aircraft, 1.4.41

[25] Rivaz, R.C., Tail Gunner, 1943 and 1996; chapters VI and VII give a graphic account of this raid by a participant

[26] Bomber Command Air Staff Note, 28.7.41, cited by Webster and Frankland, page 241

[27] Webster and Frankland, chapter VII, section 4, Daylight bombing in 1942

the background the thought that if day bombing was not sustainable a night offensive might be forced upon the RAF. Throughout the 1920s and early 1930s the reason for the search for a dual-role bomber was so that it could be used by day or by night as the strength of opposition dictated. That bombing by night might be forced upon the RAF was envisaged by the DCAS (Burnett) in 1932. He wrote that,

> If (and it is a possibility we must be prepared for) the enemy's defence by day proved unexpectedly strong, we should have to depend largely on night bombing for most of our material effect[28]

Similarly, in his review of aircraft classes in 1935, Peck feared that medium bombers might have to be used at night.[29]

A night-flying operational capability was included in all medium and heavy bomber specifications issued after 1934 and, in 1935, the Hampden and Wellington - built to day bomber specification B.9/32 - were planned to be equipped for full night operation. Thus when the degree of opposition did force the RAF to an offensive based upon night bombing, it was not ill-equipped in aircraft for that role - that it was untrained is another matter. Moreover the facility for very large bomb loads built into the 1936 bomber requirements provided some recompense for the inaccuracy of night bombing.

An important, indeed at times overriding, trend in RAF bomber requirements in the 1930s was the emphasis on speed. This was seen as essential to limit the exposure to fighter attack in daylight raids, and was a major factor in the increase in the weight of RAF bombers. For P.13/36 (Halifax and Manchester) in particular there was strong pressure for a cruising speed of 300 mph, although when issued 275 mph was specified (equivalent to a top

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[28] 9/69, Folio 76, DCAS to CAS, 18.6.32
[29] 2/2715, 6B

speed of over 300 mph). In fact, as noted in chapter 9.3.3, during design development speeds even higher than these were attributed to the P.13/36 designs, and even to the heavy bomber B.12/36 designs - maximum speeds of nearly 330 mph were estimated for both types. But when these bombers came into service in 1941, and production aircraft were evaluated, their top speed was lower than the cruising speed specified in 1936. Trials gave for the Halifax (without mid-upper turret) a top speed of 270 mph and a cruising speed of 210 mph,[30] and for the Manchester (with mid-upper turret) a top speed of 262 mph and a cruising speed of 225 mph.[31] These results further illustrate the change in performance that could arise between the Air Staff's requirements, design estimates, and production. This problem has been discussed in chapter 3.4.5 - where similar disappointing figures for the B.12/36 Stirling are noted.

However, it is doubtful if attainment of the speed estimates of the late 1930s would have allowed deep penetration raids in daylight. Later in the war even short-range attacks by fast medium bombers were usually escorted by fighters. Only the Mosquito Mark IV (the first light bomber version) was fast enough to make occasional deep penetration raids in daylight, and it is credited with a maximum speed of 380 mph and a cruising speed of 340 mph.[32]

As regards the defence of bombers, it has been shown that this was given surprisingly little attention, despite its vital importance to the concept of self-defending formations. The RAF not only failed to translate its own advances in fighter armament into complementary improvements in bomber defence, but in personnel terms, whilst much credence was given to the idea that a fighter pilot could not fly his aircraft and accurately aim his

[30] 2/1651, 193A, para. 6

[31] ibid., 173A, para.19, 1.4.41

[32] Thetford, page 215

guns, it was taken for granted that a fitter could aim the guns of a bomber - and without the need to test his eyesight.[33]

When, in 1938, it was at last accepted that "Bomber armament must naturally be correlated to that of fighters",[34] it was too late. Designs to the 1936 bomber specifications were well advanced by the time that it was accepted that cannon armament was essential for bombers, and no way of satisfactorily modifying the developed aircraft was found. Regrettable as this was thought to be, it must be doubtful that cannon armament would have provided adequate defence in daylight. (The USAAF's unescorted daylight attacks on Germany in 1943, with large formations of bombers armed with many 0.5in guns, suffered unsustainable losses.[35]) In the event, when the 1936 bombers were operated at night, their armament was of less consequence, for if the crew could not see an attacking fighter it mattered little what guns they carried.

The last pure night bomber requirement - B.3/34 (Whitley) - was used early in the war for leaflet dropping sorties, and from May 1940 for night attacks on military and industrial targets. Losses due to enemy action were very low[36] - a warning before German night attacks on Britain of the ineffectiveness of night defence before the introduction of radar aids to interception.

Air Ministry Intelligence deduced another lesson from these early Bomber Command night attacks. It suggested in September 1940 that Germany had adopted indiscriminate bombing at night - in the hope of undermining morale -

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[33] 2/956, Minutes of the second meeting of the Bombing Committee, 30th May 1935
[34] 14/380, The Gun Arrangements for Bombers, 9.8.38, section headed "FIGHTER ARMAMENT"
[35] Daniels, G. (editor), A Guide to the Reports of the United States Strategic Bombing Survey, 1981, page xviii
[36] 2/1651, AFC 98, Notes on Interception of British Bombers by Enemy Aircraft at Night, Air Tactics Branch, 12.7.40

because they knew that little effective military damage was done in RAF night raids.[37]

10.4.2 Fighters

Fighter Command operations before the summer of 1940 confirmed the expected superiority of multi-gun single-seat fighters over single bombers. They brought forth an interesting reflection on pre-war concerns about the limited ammunition capacity and endurance of RAF fighters. Dowding's advice to pilots who attacked too fast was that, "The motto should be - 'Keep cool, there is no hurry. You have an hour's petrol and only 18 seconds (sic) fire capacity.'"[38]

The Hurricane and Spitfire were not called upon to operate in their planned home defence role against formations of bombers until the commencement of the Battle of Britain in July 1940. In terms of the operational requirements (F.10/35) from which these aircraft derived, this crucial battle was quite unlike that which had been expected in two ways.

First, as with German fighters attacking RAF bomber formations, but contrary to pre-war expectation, single-seat fighters were found to be very effective against unescorted formations of bombers. Second, the German Air Force adopted fighter escort for its bombers - feasible from bases in France in a way that it would not have been from Germany. Fighter Command was therefore faced with fighter *versus* fighter combat. This had not been envisaged when fighter policy in the 1930s put the emphasis on speed at the expense of manoeuvrability. Indeed there were some doubts as to whether dogfights were

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[37] PRO: AIR 9/443, Notes of Meeting held on 23rd October 1940 to Discuss Bombing Policy, DDI3 to DoI, 24.9.40

[38] PRO: AIR 16/299, Lessons learned from Air Combats, 1A, 25.10.39, para. 4

physiologically feasible. The RAF Manual of Air Tactics stated that,

> Manoeuvre at high speeds in air fighting is not now practicable, because the effect of gravity on the human body during rapid changes of direction at high speed causes a temporary loss of consciousness, deflection shooting becomes difficult and accuracy is hard to obtain.[39]

This statement was issued before fast monoplane fighters had come into service. When it was found that dogfights between such fighters were possible, the issue of manoeuvrability *versus* speed was summed up by Dowding at an Air Fighting Committee discussion in February 1940. He said that if two fighters were determined to stay and fight, it would eventually resolve into a circling match, and the one with the smallest turning circle and best control would win. But if the other fighter had sacrificed manoeuvrability to get a higher performance, and did not choose to fight, it need not.[40]

Despite the unanticipated tactical situation, the Hurricane and Spitfire, coupled with a radar-based fighter control system, whilst not able to prevent the daylight bombing of London, did make it militarily ineffective and unsustainable. On the other hand, the considerable resources devoted to attempts to devise a form of fighter thought to be more suitable to attack formations of bombers proved not only to have been unnecessary, but - as feared by Dowding when this idea was gaining momentum through the Novel Fighter competition - led to fighters like the Defiant which were vulnerable to enemy single-seat fighter escorts.

On finding that day attacks by its purpose-designed day bombers were too expensive, the main German bomber force followed the RAF in concentrating on night attacks.

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[39] 10/1430, chapter VIII, para.4

[40] 5/1126, Minutes of 19th meeting of AFC, 12th February 1940, para. 51

Attacks in daylight were continued along the lines proposed by Chamier (discussed in chapter 4.2.2.1), with fighters carrying bombs. These "changeling bombers" were, as anticipated by Chamier, fast enough to make interception difficult, and able to defend themselves if intercepted.

The RAF's plan for defence against night attacks had always been to employ its single-seat fighters, to the extent that the Air Staff were prepared to sacrifice their performance as day fighters to obtain safe night flying - sometimes in vain, as with the Bulldog. Night defence by single-seat fighters had appeared to be reasonably successful in air exercises. But exercises against bombers which flew along known routes, and with their navigation lights on, were no test of the ability of a fighter pilot to see and attack a bomber at night in wartime. As with German defences against RAF night bombing, there was found to be no effective defence until the introduction of Airborne Interception radar and Ground Controlled Interception. Nevertheless, the belief that single-seat fighters could be effective at night persisted amongst the Air Staff, and contrary to Dowding's wishes, more squadrons were employed in that role - to little effect.[41] (Later in the war, German single-seat fighters achieved some success at night against RAF bombers when their attacks were concentrated in time and space, could be illuminated by radar guided searchlights, and silhouetted against the flares and fires of the target area - the so-called *Wilde Sau* tactics.[42])

Airborne Interception radar was under development in 1938 (then known as R.D.F.2). It was clear that a two-seat fighter would be needed for night fighting because a pilot could not fly the aircraft and operate the radar.[43] Fortuitously, the Bristol Beaufighter was coming into

[41] Collier, B., The Defence of the United Kingdom, 1957, pages 254-255

[42] Hinchliffe, page 131

[43] 2/2964, 18A, Note of a Meeting ... on 16th November 1938, page 2

service. The origin of this aircraft as a quickly available cannon fighter has been noted in chapter 9.2.1. Its capacious fuselage could take radar equipment and an operator, and it became the first successful night fighter.

Yet apart from night fighting, and despite its doubts about the effectiveness of single-seat fighters, the Air Staff chose the right priorities for this class in other respects. From the early 1930s it moved towards placing speed and armament above other performance characteristics, and accepted a relatively low endurance to get a high maximum speed. This policy led to the development of fighters which were a match for their main opponent in 1940, the Me(Bf) 109. Indeed, comparative trials with a captured Me 109 concluded that the Spitfire was better in every respect.[44] (Spick says that German trials with a captured Spitfire came to the opposite conclusion. He suggests that, "in practice there was little to choose between the two types".[45])

In its plans for the armament of fighters the Air Staff was far ahead of those of any other air force. The literature reports that in 1934, when eight wing-mounted 0.303in machine guns were specified for F.5/34, the German Me 109 was designed to carry two 7.9mm (0.311in.) machine guns, later increased to four.[46,47] Design of the Focke-Wulf Fw 190 started in 1937-38 and was thus contemporary with F.18/37. It was initially armed with four rifle-calibre machine guns[48,49] whereas Air Staff Requirement F.18/37 called for twelve.

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44 2/1651, 87A, AFC 99, Comparative Trials between a captured Messerschmitt 109 and British Fighters

45 Spick, M., The Ace Factor, 1988, page 82

46 Cooper, M.. The German Air Force 1933-45, an Anatomy of Failure, 1981, page 52

47 Dressel, J., and Greihl, M., (trans. M.J. Sheilds), Fighters of the Luftwaffe, 1993, page 36

48 Green, W. & Swanborough, G., Focke-Wulf Fw 190, 1976, page 33

49 Smith J.R., & Kay, A., German Aircraft of the Second World War, 1972, page 175

The armament of American fighters also lagged behind that adopted for RAF fighters. In 1934 the Curtiss P-36 was designed with but two 0.300in machine guns - later increased to four. The Curtiss P-40 (Tomahawk when operated by the RAF), first flew in 1938 armed with two 0.5in machine guns,[50] with two 0.300in added later.[51] Operational requirements for the better armed American fighters of the Second World War were no doubt drawn up some time before these aircraft entered service in 1942 - Brodie says the requirements which led to the P-38 (Lightning) were issued in February 1937.[52] But by 1942 most RAF fighters in service were armed with either two 20mm cannon plus machine guns or four cannon.

The Air Staff had first called for an armament of four 20mm cannon in 1935. The Westland Whirlwind to specification F.37/35 was much delayed in development, and arrangements were made to arm the Spitfire and Hurricane with 20mm cannon. Cannon-armed Spitfires made a brief appearance in the Battle of Britain, by which time German fighters were armed with cannon, but of a type much inferior to the Hispano gun which was coming into use by the RAF. Indeed, Wallace says that the 20mm Oerlikon as used by the German Air Force had less penetration than the RAF's 0.303in machine guns. He adds that theory (both RAF and German) had been that an explosive charge would suffice, but this was proved wrong, particularly when aircraft were armoured against machine gun ammunition.[53] Indeed, after a year of experience of air fighting, it was found that,

> One of the principal lessons of the war is that the airframe can stand a very large number of strikes from all types of ammunition up to and including 20 m.m. without failure.[54]

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50 Bradley, M.E., "The XP-40", Aerospace Historian, Vol 25 (1978), No.3

51 Swanborough & Bowers, pages 221 and 231

52 Brodie, W.M., The Lockheed P-38 Lightning, 1991, page 16

53 Wallace, page 181 "German Guns"

54 20/84, ACAS(T) to D of Plans, 12.10.40, Vulnerability of Aircraft

This finding confirmed the Air Staff's view in 1935 that the single engine-mounted cannon then being developed in France (and also in Germany for the Me 109B[55]) would not give a sufficient density of fire.

10.5 OPERATIONAL REQUIREMENTS FOR A NIGHT BOMBING POLICY

In chapter 4.2.2.3 the RAF's implied doubts about the feasibility of long-range bombing operations in daylight are discussed, and in chapter 6.1 the Dowding's and Pierse's fear that deep penetration bombing raids would be vulnerable to attack by multi-gun fighters is noted. This section briefly discusses the impact on operational requirements if these concerns had led the Air Staff to base its planning on the assumption that long-range unescorted bombing by day would be too costly.

It is assumed that no change in strategic policy would have arisen, since, as noted in chapter 2.2.1, the Air Staff saw its counter-offensive strategy as appropriate for, "war between two nations who have no land frontiers in common". Thus as there were no plans to send a British army force to the continent of Europe until the late 1930s,[56] the alternative policy of planning the home defence air force primarily to support ground operations would not have arisen. Moreover, the relative vulnerability of London was high, so that an enemy might be able to sustain daylight attacks when the RAF could not, and, if he was forced to night attacks, it was feared that these would also be devastating despite the expected loss of accuracy.[57] Thus a deterrent counter-offensive strategy would still have been seen as appropriate for home defence.

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[55] Janes Fighting Aircraft of World War II, Studio Editions, 1989, page 176

[56] Bond, B., British Military Policy between the Two World Wars, 1980

[57] 41/14, Appendix 6, Annexure A, Estimate of Effect of Air Attack on Docks

There were known to be two options to implement a counter-offensive if it was believed that day bombing by unescorted formations of bombers was not a feasible operation of war. These were night bombing or fighter escort for day bombers.

For an offensive based upon night bombers one might suppose that the first requirement to be relaxed would be defensive armament, for it was recognised that this would be of little use in darkness. It had been Air Staff policy to arm night bombers to the same standard as day bombers only because they might have to undertake part of their missions in daylight in the summer months, and might be used by day when an enemy's defences had been weakened. If day operation had been thought to be not feasible these considerations would not apply. Even so, in the thinking of the 1930s it is unlikely that armament would have been dispensed with entirely. A tail turret would have been thought necessary for crew morale, and as a threat to an attacking fighter should it have sighted the bomber. (One of the oddities of Bomber Command's night offensive is that it operated fully armed and crewed day bombers at night, although there was a firmly held opinion - by Arthur Harris in particular - that only a tail turret could be useful at night.[58])

Otherwise, the trend of bomber development would sensibly have moved towards large bomb loads to counteract the expected relative inaccuracy of night bombing as compared with day. Cruising speed would need to be no more than sufficient to complete deep penetrations of German airspace in darkness throughout most of the year.

In many respects the original requirement for the medium bomber, P.13/36, came close to this specification when overloaded take-off is taken into account, but with the important difference that a high cruising speed was

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[58] 5/1126, Minutes of 21st meeting of AFC, 5th April 1940, paras. 39 and 43

demanded to limit exposure to fighter attacks during day raids. In fact, as noted above, by the time the aircraft designed to this requirement were ready for operations their cruising speed was little more than 200 mph - more suitable for their enforced role of night bomber than for that of high-speed day bomber aimed for in 1936. Very high speeds for night bombers became important only after the introduction of radar aids to interception, as evidenced by the relative invulnerability of the Mosquito.

Acceptance that daylight bombing was unsustainable would have affected not only bomber operational requirements, for Air Staff fighter requirements were also guided by belief in the efficacy of daylight bombing. Faith in self-defending formations of bombers was extended to potential enemies - more so in view of the vulnerable position of London - and this led to many attempts to find a type of fighter to overcome the supposed failings of fixed-gun fighters. Furthermore, the belief that devastating day attacks on London could not be prevented led to the view that night attacks would be of secondary importance, and that therefore the development of a dedicated night fighter was not justified. Instead, all fighters were required to have a day and night fighting capability.

Had night bombing been seen as the main threat, then the Air Staff could be expected to have put more emphasis on the development of a night fighter, and this would have been along the lines considered in the mid-1920s and early 1930s - a twin-engined aircraft with a very good view for the crew. (Such a project was included in the draft Air Estimates for 1931.[59]) It must be remembered that, although it was found in war that the interception of night bombers by fighters of any sort was negligible before the advent of airborne radar, this was not part of the Air Staff's reasoning between the wars.

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59 20/68, page 91 and page 101, item 4. Twin Engined Night Fighter

Whatever efforts might have been made to improve defence against night attacks, a strong day defence would also have been required to force an enemy to concentrate on night attacks. There is no reason to think that the aircraft seen as required for this purpose would have been any different than those which were specified, particularly as it was believed that these already included a secondary night fighting capability.

Fighter escort for bombers in daylight was the alternative policy the RAF could have considered had it assumed that attacks by unescorted day bombers were untenable. Throughout the 1920s and 1930s the Air Staff argued that fighter escort was tactically unsound, diverted resources from bombers, and in any case was not technically feasible. Although later in the war found to be unsound in its tactical appreciation, the Air Staff was correct in its assumption that an escort fighter designed in the mid-1930s, with the range needed for war with Germany, could not have a performance comparable with that of the short-range fighters which the defence would employ. This was demonstrated by the fate of the German Me 110 long-range fighter - as good a design as the state-of-the-art of the 1930s allowed[60] - when confronted by the RAF's single-seat fighters.

The later success of the North American P-51B Mustang as an escort fighter is not a fair comparison. Designed to a British specification in 1940, it benefited from improved knowledge of aerodynamics, the development of drop tanks, and above all advances in engine development. Indeed, it can be added to the 'modified' F.7/30 and the P.13/36 designs as an instance where the replacement of the original engine by the Merlin transformed its performance from the mediocre to amongst the best.

60 Price, Fighter Aircraft, pages 14-15

If an effective long-range fighter was not a practical possibility then the Air Staff's doctrinal arguments against escort fighters, right or wrong, were irrelevant.

Reference has been made on a number of occasions to the RAF's interest in the concept that the defensive power of a formation of bombers might be increased by including some bombers with increased armament in place of bomb load. This form of escort was not put into practice by the RAF, but as noted in chapter 2.3.2, when tried by the USAAF it was found to be ineffective.

10.5 SUMMARY

It has been demonstrated throughout this thesis that in the inter-war years the Air Ministry fostered the development of advanced aircraft through its operational requirements. Contrary to many published views, the Air Ministry encouraged the development of monoplane fighters, recognised from the late 1920s the need for multi-machine gun fighter-armament, and, as early as 1935, its replacement by 20mm cannon. The Ministry saw the need for fast long-range bombers for war with Germany, seized the apparent opportunity to call for very large bomb loads, and sought power-operated multi-gun turrets at a time when German and American designs had none.

Certainly there were problems of coordination and management, but these are to be found in any large organisation - particularly during periods of rapid technical change and expansion.

In the first eighteen months of war with Germany the RAF's fundamental assumption which had guided its operational requirements was found to be wrong - the relative effectiveness of fighters and bombers in daylight was the opposite to that expected. Daylight bombing by self-defending formations of bombers was soon found to be untenable in the face of fighter opposition. The corollary of this experience was that RAF single-seat fighters were equally effective against German bomber formations. Breaking up formations of enemy bombers did not require multi-seat turret fighters, indeed they were themselves exposed when the bombers were escorted by single-seat fighters.

Another lesson learnt from the first year of operations was that despite the insistence throughout the 1920s and 1930s that the RAF's standard fighter should have a night flying capability, they were able to provide little defence against night attacks.

All was not lost. Other air forces made the same misjudgements, and overall the operational requirements set by the RAF in the 1930s led to bombers and fighters which were at least as effective as those of other nations. Moreover, most were adaptable to the not wholly unforeseen pattern of air warfare which emerged. The long sought "dual-purpose" bombers were effective in the night bombing role which was forced upon them, and the multi-gun single-seat home defence fighters were effective when unexpectedly confronted with enemy fighters - as Dowding had predicted many years before.

APPENDIX

THE AIR MINISTRY

Air Staff and Technical Departments: frequently mentioned posts and holders 1927-1939
(date of appointment with first mention)

year	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
CAS	*Trenchard* *1.3.19*	*Trenchard*	*Trenchard*	*J.Salmond* *1.1.30*	*J.Salmond*	*J.Salmond*	*G.Salmond* *(1.4.33)* *Ellington (22.5.33)*	*Ellington*	*Ellington*	*Ellington*	*Ellington*	*Newall* *1.9.37* ACAS *Douglas* *17.2.38*	*Newall* *Douglas*
DIRECTORATE OF OPERATIONS AND INTELLIGENCE													
Director (and DCAS)	*Newall* *12.4.26*	*Newall*	*Newall*	*Newall*	*Burnett* *6.2.31*	*Burnett*	*L-Hewitt* *1.2.33*	*L-Hewitt*	*Courtney* *6.1.35*	*Courtney*	*Peirse* *25.1.37*	*Peirse*	*Peirse*
DDOIs	*Freeman* *12.4.26*	*Freeman*	*Freeman*	*Freeman*	*Peirse* *18.12.30*	*Peirse*	*Peirse*	*Harris* *3.8.34* *Peck* *13.1.34*	*Harris* *Peck*	*Harris*	*Slessor* *17.5.37*	*Slessor*	*Slessor*
FO1/OR	*Welsh* *21.9.26*	*Welsh*	*Welsh*	*Welsh*	*Maund* *8.9.30*	*Maund*	*Williams* *16.1.33* *Sorley* *17.1.33*	OR *Oxland* *15.10.34* *Sorley*	*Oxland* *Sorley*	*Oxland*	DDOR *Oxland*	*Saundby* *18.1.38*	DOR *Saundby*
DEPARTMENT RESPONSIBLE FOR RESEARCH AND DEVELOPMENT													
AMSR	*J.Higgins* *27.12.26*	*Higgins*	*Higgins*	*Higgins*	*Dowding* *1.9.30*	*Dowding*	*Dowding*	*Dowding*	AMRD *Dowding*	*Freeman* *1.4.36*	*Freeman*	AMDP *Freeman*	*Freeman* DGRD *Tedder* *20.7.38*
DTD	*Forbes* *1.11.26*	*Chamier* *6.5.27*	*Holt* *7.12.28*	*Holt*	*Cave* *1.7.31*	*Cave*	*Cave*	*Cave*	*Verney* *17.9.34*	*Verney*	*Verney*	*Verney*	*Hill* *14.8.38*
DDTD		*Gill* *12.12.27*	*Gill*	*Gill*	*Gill*	*Buchanan* *1932*	*Buchanan*	*Buchanan*	*Buchanan*	*Buchanan*	*Buchanan*	*Buchanan*	DDGP *B'anan*
ADArm			*Thompson* *21.1.30*	*Thompson*	*Thompson*	*Thompson*	*Thompson*	*Keith* *2.10.33*	*Keith*	*Keith*	DDTArm *Baker* *9.7.36*	*Baker*	*Baker*
RDA3	*Liptrot*	*Liptrot*	*Liptrot*	*Liptrot*	*Liptrot*	*Liptrot*	*Liptrot*	*Liptrot*	*Liptrot*	*Liptrot*	*Liptrot*	DAD(A) *Liptrot*	AD *Liptrot*

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References to minutes give the originator and recipient, and date in the format xx.xx.xx, which was Air Ministry practice for internal communications. Where the document is a complete Air Ministry file, it may contain appendices/enclosures which are numbered xA, xB etc. - these designations are given where appropriate. Files which are collections of selected documents usually have Folio, Item or page numbers - which are given where possible. Otherwise a reference can be recognised by the date.

Books

On first citing the author(s)' surname and initials, title underlined, and date of publication are given. The page number of the reference is given where appropriate

On subsequent citing only the author(s)' surname and page number of the reference is given. Where necessary to avoid ambiguity a shorten title is included.

Journals

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